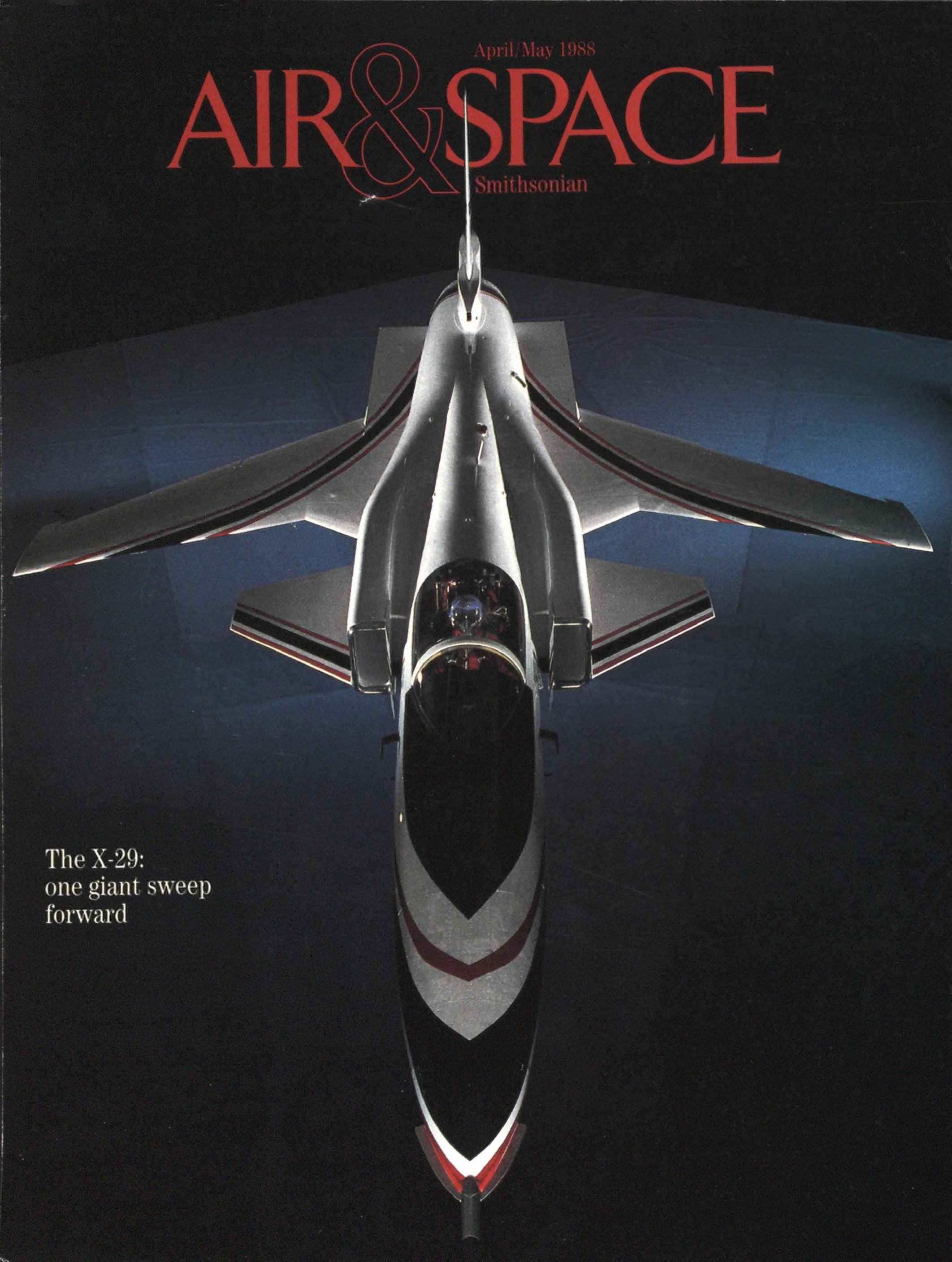
April/May 1988

AIR & SPACE

Smithsonian



The X-29:
one giant sweep
forward

NASA photo:
Turbine hot-streak analysis.

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April/May 1988
Volume 3, Number 1

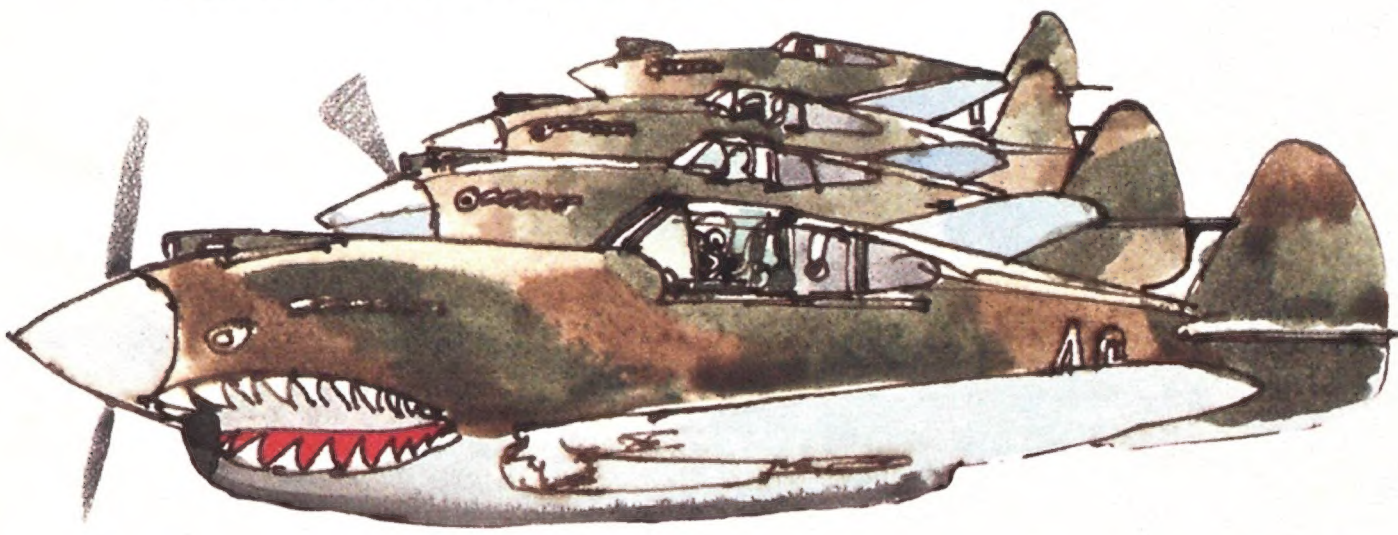
AIR&SPACE
Smithsonian

Contents

Cover: *Even on the ground the X-29 looks like it's flying in reverse. (Courtesy Grumman Corp.)*

Special Poster Insert

This issue's poster is an international space hall of fame, showing every person who had orbited Earth by the end of 1987. Two hundred and four space explorers, with a list of their missions, appear in this portrait gallery. The reverse side features a lineup of the world's spacecraft fleet, from Yuri Gagarin's Vostok to the space shuttle.



AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bimonthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, DC 20560.

Subscription price: $18 a year in U.S. possessions, $24 elsewhere. Eighty-five percent of dues is designated for magazine subscription. Single-copy price: $3.50. Second-class postage paid at Washington, DC, and additional entry points. Editorial offices: National Air and Space Museum, Washington, DC 20560. Advertising and circulation offices: 420 Lexington Ave., New York, NY 10170. Members: Address all subscription correspondence and change-of-address information to P.O. Box 53261, Boulder, CO 80322-3261. Postmaster: Send address changes to *AIR & SPACE/Smithsonian,* P.O. Box 53261, Boulder, CO 80301-3261.

When Dreams Take Wing

It is the nature of museums to become involved in projects at their ends rather than at their beginnings. So it's unusual that twice in the past two years the National Air and Space Museum has had the experience of godparenting exciting projects in aviation research.

In both instances the scenario was the same. Enthusiasts with impressive credentials came to the Museum with projects that had interesting educational possibilities but lacked the commercial potential needed to attract traditional investors. They asked the Museum to provide seed money for feasibility studies and, if the ideas proved sound, to help find outside funding by providing visibility and assisting with publicity.

The first arrival was aviation pioneer Paul MacCready, who dreamed of recreating a full-size, wing-flapping pterosaur—a large flying reptile that lived 70 million years ago, during the age of the dinosaurs. MacCready's delightful venture into paleo-aeronautics is already well known to Museum visitors; the robot pterosaur, equipped with a computer brain, flies successfully every day on the big screen of the Museum's IMAX theater in our film *On the Wing*.

The second project, Daedalus, is named after the inventor of Greek myth who escaped from prison on the island of Crete using wings he built of feathers and wax. If all goes as scheduled, the project will have reached its emotional peak this spring, when a young athlete climbs into an airplane of breathtaking fragility and beauty and flies, with power provided by his own heart, lungs, and muscles, from Crete to the mountainous Greek island of Thera.

Ten years ago the first successful human-powered airplane flew just one mile. Our modern Daedalus will need to fly 70 miles—a journey that requires four to six hours of continuous strenuous effort, stretching the limits of both human endurance and aircraft design. In another sense the distance traveled may be much farther—the underlying motive of the Daedalus team is to remind us that the dream of human flight goes back through the centuries to that mythical engineer.

The National Air and Space Museum is involved because we believe this kind of effort supplements our traditional programs. These projects demonstrate, to young people especially, that while technical training and painstaking effort fuel engineering and scientific achievement, excitement and adventure are among the rewards.

For the Museum the rewards are substantial. By their very nature, outside projects bring the Museum and its staff in contact with diverse organizations and interesting people. The pterosaur project, for example, put us in touch with Paul MacCready's iconoclastic, ecology-minded engineering group AeroVironment, Inc. The company is famous for its off-the-wall assignments, such as the design of a solar-powered car, the GM-Hughes Sunraycer, which late last year won a race across Australia. The Daedalus Project introduced us to nearly three dozen undergraduates, graduate students, and faculty members of the Massachusetts Institute of Technology, as well as researchers from the Yale School of Medicine, who considered the human side of the question. All were involved in the year-long feasibility study the Museum helped fund, which concluded that the Daedalus Project's proposed flight was theoretically possible.

After two diverse ventures into the world of exotic aerospace research, we've found the experience can be very positive, provided the project meets certain criteria. It doesn't have to be serious—it may help if it is not—but it does need to be imaginative, unique, and challenging. And while inspiration can arise from many sources, even the ancient or mythical, success ultimately depends on motivation and a solid technical base. The gods of technology are unforgiving. In fact, one of the most important lessons of all may be that there are no shortcuts in building any successful new flying machine. Only the scale differs.

—Brian Duff works on special projects at the Museum.

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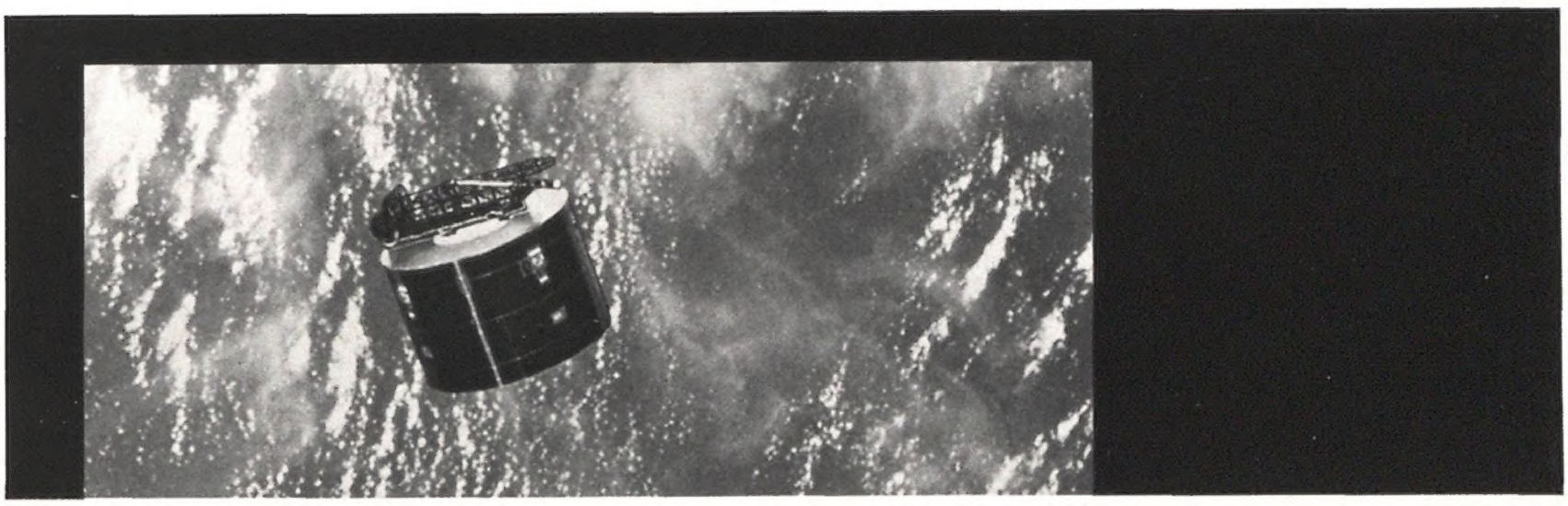


The Space Station's potential for improving life on our planet is boundless. Yet the cost of building and maintaining it comes to roughly two cents a day for every American. Your support for the NASA Space Station will make a difference. So get your two cents' worth in. Say yes to America's manned space station program.

MCDONNELL DOUGLAS

Letters

Indefensible

One of the most regrettable aspects of U.S. aerospace policy in the 1980s is the pervasive influence of the defense establishment. It's distressing to see an acute observer like T.A. Heppenheimer write in "The Hypersonic World of Robert Williams" (February/March 1988) that the National Aerospace Plane project would "logically fall under [the Air Force's] domain" and that the defense department's "big budget" is a decisive factor in the development of the plane.

When President Eisenhower set up NASA, he specifically—and with extraordinary wisdom—directed that it be a strictly civilian agency with primacy over the nation's civilian space program. He feared military domination of U.S. activities in space, an indication of his general mistrust of what he would later dub "the military-industrial complex." Over time, as post-Apollo NASA faced difficulties in establishing cohesive national space policies and as the Reagan administration adopted policies favoring the defense department, the U.S. effectively lost its civilian space program.

Obviously, the aerospace plane and associated technology will have military value. But its potential nonmilitary impact is far more valuable and necessary. The advancement of technological capability is a goal to be pursued for the common good, including, but not exclusively for, the common defense.

Irv Paskowitz
Derwood, Maryland

T.A. Heppenheimer replies: If Mr. Paskowitz objects to military influence in aerospace, perhaps he should stay away from civil aviation and long-distance phone calls. The Boeing 707 and 747 were developed with heavy Pentagon support, and most communications satellites have been launched by converted military rockets.

I do not believe that Dwight Eisenhower in his wisdom anticipated the feckless, overblown bureaucracy that NASA has become. NASA needs a healthy dose of competition and the Air Force is just the outfit to supply it. If NASA wants to win back space primacy, first it must show that it can do the job.

BASE Hit

I was pleasantly surprised to see "Geronimo!" (February/March 1988). As a dedicated parachuting enthusiast with over 5,000 jumps and nearly 20 years' experience, I always appreciate an upbeat article on any aspect of parachuting. However, there were some critical misperceptions in the article.

Most importantly, it must be emphasized that the participants of BASE jumping should include only free-fall parachutists who have years of training and experience. Even among this select group BASE jumping is definitely not for everyone. Unfortunately, BASE jumps are often attempted by inexperienced jumpers who are relying on luck more than skill to survive. Any attempt by an individual to make a BASE jump without prior parachuting experience is best considered a suicide attempt.

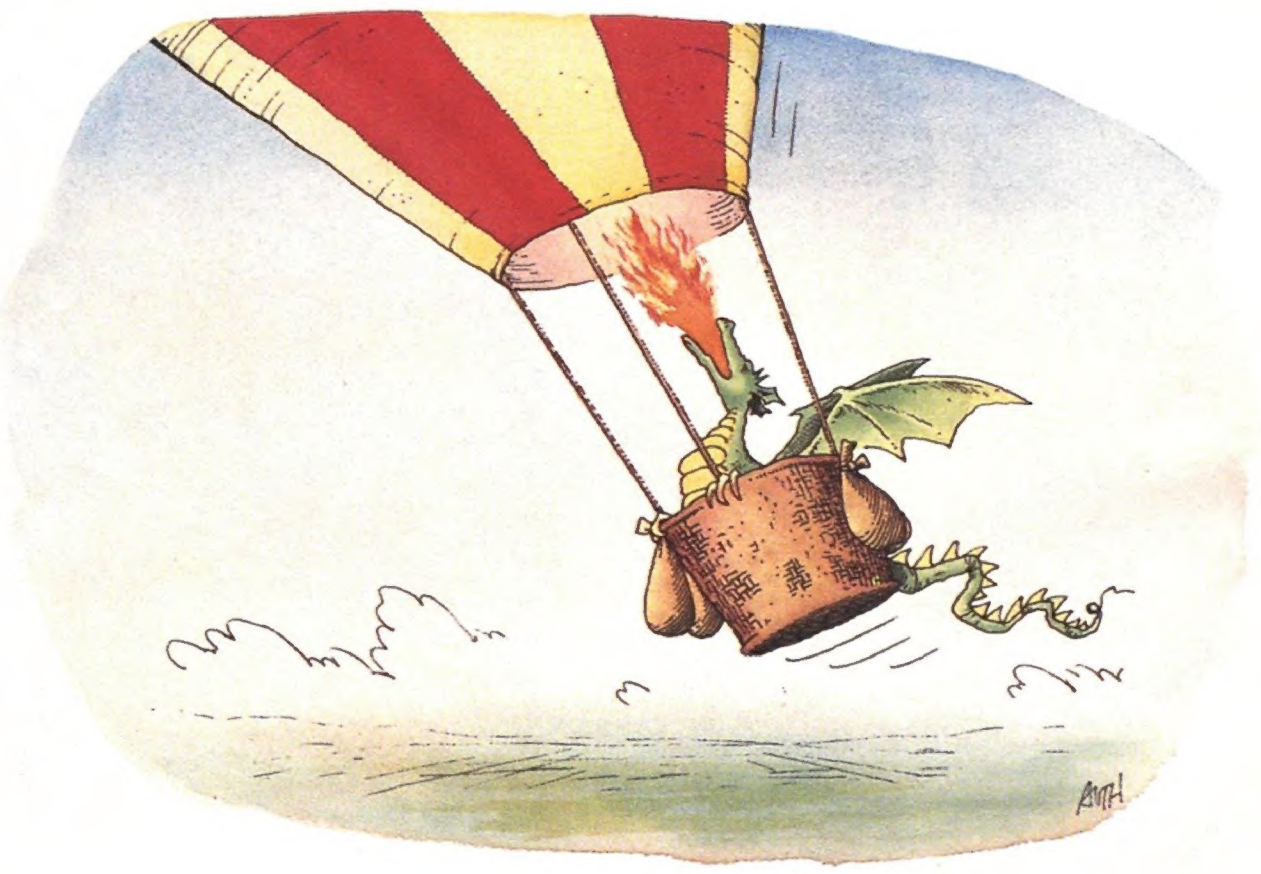
The article gives the impression that BASE jumping was illegal only in its early days. Unfortunately, one of the major obstacles to the development of safe BASE jumping sites is the fact that it has been totally outlawed at virtually every tall cliff, bridge, building, and antenna in the world. At the New River Gorge Bridge it is permitted only once annually.

Jerry L. Swovelin
Carlsbad, California

Flying, Part II

I would like to inform the curious pilots who wondered about the fly's abilities (Letters, February/March 1988) that the fly does not land on the ceiling through an aerobatic maneuver like a half-roll or a half-loop. He does it by an acrobatic maneuver—a half-somersault.

Some British scientists asked the same question a few years ago. They had at their



disposal the means to find out. Using strobe lights and high-speed sequence cameras, they found that the fly approaches the ceiling in level flight, raises its forefeet to the ceiling to make contact, then pivots about on those feet to come to rest on the inverted surface.
Peter M. Bowers
Seattle, Washington

The Cover Story

You take the cake for impressive cover pictures with "Sweden's 'Flying Weapon' " (February/March 1988). Your cover story overwhelmed me and all others who dare to enter my office and read my copy of *Air & Space/Smithsonian.*
Mark Paloian
Oxford, Connecticut

The statement that the Swedish Air Force has never been tested in combat is not, strictly speaking, true. During the Winter War between Finland and Russia in 1939, the Swedes sent a volunteer group, Flygflottilja 19, to serve with the Finns in their gallant resistance against the invaders.

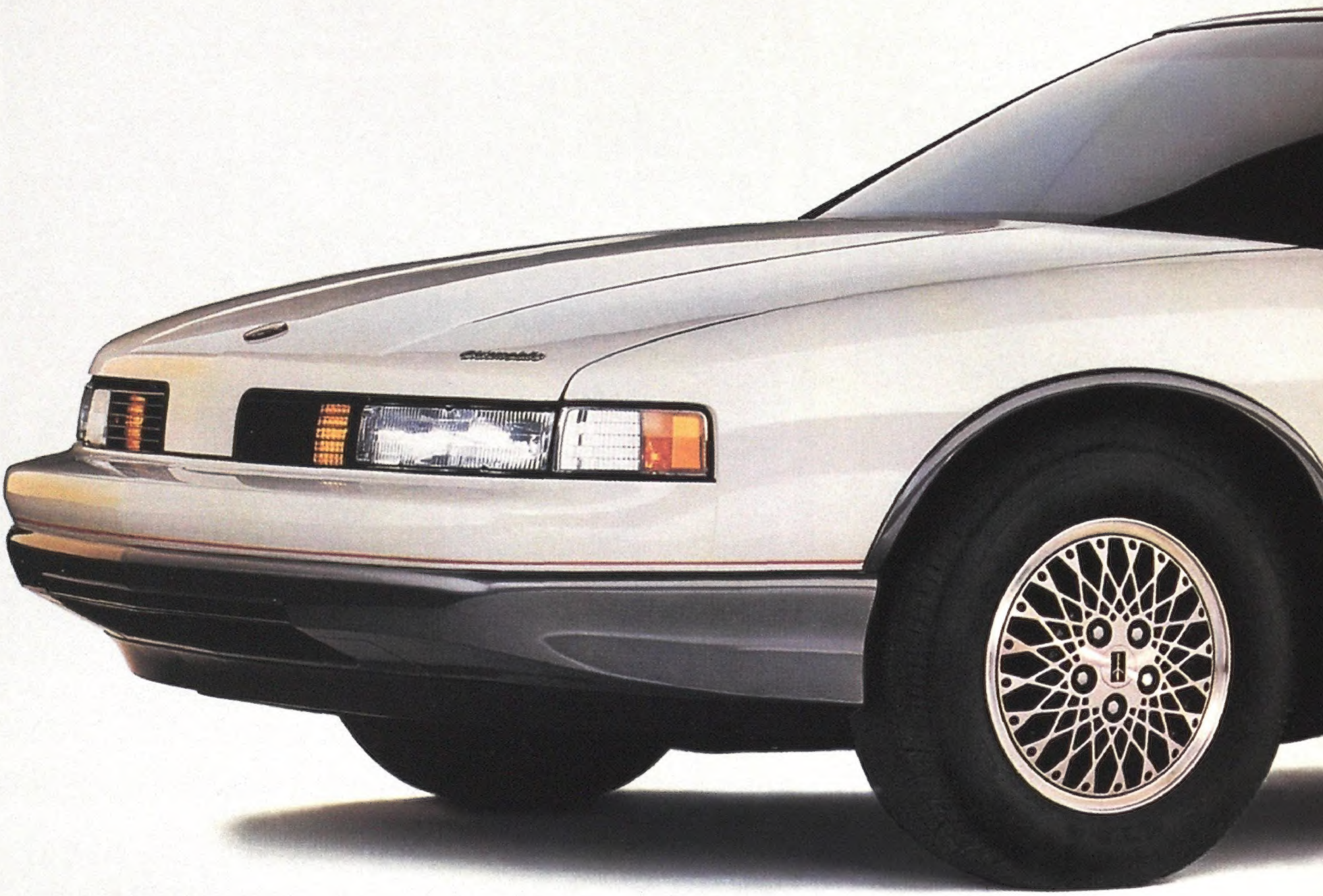
F-19, equipped with Gloster Gladiators and radial-engine versions of the Hawker Hart, spent 62 days in combat, logging over 600 combat hours and scoring a kill ratio of better than three to one. Given the equipment and the climate, this record is nothing short of astounding.

Any opponent facing the Flygvapnet in the future would do well to study Swedish history.
Robert E. van Patten
Bellbrook, Ohio

Let me assure you that the Swedes are not neutral. By doing nothing the Swedes are on the side of evil. In a battle between good and evil there is no neutrality.

The insidious workings of Communism can be found all over Sweden. By doing nothing 45 years ago the Swedes now carry a large part of the responsibility for half of Europe being under Communism. Swedes are not neutral, they have just shirked their responsibility for Europe.
Jack Auer
Glens Falls, New York

Air & Space/Smithsonian *welcomes comments from readers. Letters must be signed and may be edited for publication. Address letters to* Air & Space/ Smithsonian, *National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.*



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Unfortunately, making cars this good doesn't make enough to go around.

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Co-founders of The Planetary Society: Bruce Murray, Professor of Planetary Sciences, California Institute of Technology (seated left); Carl Sagan, Director, Laboratory for Planetary Studies, Cornell University (seated right); Louis Friedman, Executive Director (standing).

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AA03

That's Entertainment

What if you gave an airshow and nobody came? No one to stand solemnly, eyes skyward, while the Chutin' Stars plummet earthward carrying the American flag. No one to *oooh* and *aaah* when the Snowbirds' nine jets close ranks for a formation flyby. No one to wonder why the Daring Damsels would leave the safety of the cockpit to crawl around on the wings of a Stearman.

To make sure that nightmare never occurs, more than 900 airshow performers, organizers, sponsors, and military representatives gathered in Las Vegas last December for the annual International Council of Air Shows convention. The four-day event, held at the Riviera Hotel, included such seminars as Event Marketing, Staging Your Show, Selling Your Act, Securing a Sponsor, Insurance, and Guest/VIP Activities. Performers manned booths and showed videos of their performances while organizers signed up acts for the coming year—everything from the Acme Duck & Airshow Company to a group that re-enacts the Pearl Harbor raid.

"Airshows provide the entertainment of flying to a public that all too often sees aviation as a series of jetport walkways and crowded terminals," said Federal Aviation Administration's T. Allan McArtor in a videotaped message to Council members. "The airshow industry performs a great service to aviation."

Phil Jordan

From the barnstorming antics of the 1930s, airshows have evolved into a multimillion-dollar industry, and no potentially profitable void remains unfilled. One civilian team, the Redhawks and Team America, has flown into the fray with its Italian Siai Marchetti SF.260s, promising to "amaze pilots and spectators alike." And then there's the Coors Light Silver Bullet Jet Team with its Acrojet Specials, the world's smallest jets.

Large corporations cover expenses for a number of acts, such as the Ray-Ban Gold aerobatic team and the Pepsi Skywriters. Such sponsorship is a boon for the performer but can create a headache for an airshow organizer who needs local sponsors to kick in the balance. "We contracted with the Blackhawks," says Rose Mary Hicks, director of the Texas Air Expo, "but by showtime, they had become the Holiday Inn Aerobatic Team." Such airborne advertising discourages local businesses from providing airshow funding. "You're not going to get a car dealership to sponsor airplanes with 'Holiday Inn' written all over them," adds Hicks.

But there is still an abundance of acts to choose from—more, in fact, than there are slots to fill. Teams must compete for spots in shows across the country. Claiming the status of the "only" something or other apparently hones the competitive edge. The Northern Knights have "the only multi-engine aerobatic team" and "the only paraplegic airshow pilot." Krashbern T. Throttlebottom has Ace, "the world's only airshow dog." Craig Hosking does "the world's first inverted takeoff and landing" in "the world's only airplane" capable of doing so. (His Pitts has an extra set of landing gear on the top wing.)

If you're not an "only" it helps to be either a last or a loudest. Johnny Kazian of Franklin Airshows claims he's "the last of the real wingwalkers" (which makes you wonder how other wingwalkers manage to fake it). And Steve Wolf guarantees that his performance in *Samson,* a homebuilt biplane with a 450-horsepower Pratt & Whitney round engine, will "thrill spectators with its fast-paced aerobatics, and noise and smoke beyond belief."

The Royal Albanian Team (RAT) has all bases covered. They bill themselves as the last *and* only noisy aerobatic team from Albania, flying two "3,500 hp Pratt & Whiskey powered PiG Special supersonic biplanes" that bear a suspicious resemblance to a pair of Pitts S-2s. General Ividiches Tskratchit narrates as the duo performs the Welded Wing Takeoff, the 32-Point Vertical Roll, the Inverted Telegraph Wire Cut, the Cartop Landing on a Speeding Convertible, and the Salute to Fallen Dictators Baby Doc Duvalier, Ferdinand Marcos, Idi Amin, and Jim and Tammy Bakker.

Only military jet teams, like the Blue Angels, the Thunderbirds, and Canada's Snowbirds, needn't compete for slots—the teams are in great demand because the crowds and free publicity they attract practically guarantee a successful show. In fact, the Department of Defense sent Major Brent Jones to explain why most airshows *can't* book the most popular military teams. Jones says the defense department received 231 requests for the Blue Angels and 220 for the Thunderbirds for 1988. The Thunderbirds can accommodate 77; the Angels, 46.

The typical airshow director, up to his eyeballs in performers, sponsors, and Porta-Johns, all the time worrying if income will cover outgo, may find it hard to remember that the main point is to bring people closer to aviation. Jesse Woods, a veteran barnstormer who took her first airplane ride in 1928 and soon after joined the airshow circuit with her husband's act, Jimmy Woods and the Flying Aces, drove home that point with some reminiscing. "All the things I learned were pretty good," she said, "except for wingwalking, parachuting, and the rope ladder. Those don't help you get along in life much." But it was a living. On a good day the Flying Aces brought in up to $800. "Our pilots made $50 a week," said Woods. "That's more than airline pilots were making.

"Where would the airlines be," Woods asked, "if it wasn't for the guys who brought aviation to the grass roots, where people had never seen anything but a horse's rear end?"

—Elaine de Man

Redesigning the Rush Hour

Paul Moller, a former professor of aerodynamics and engineering, built his first flying saucer in 1965. The two-engine XM2 hovered barely a foot above the ground. The eight-engine XM3, a project he undertook with his students at the University of California at Davis, did not fly at all.

Now, hundreds of thousands of work hours and $10 million later, the XM2, -3, and -4 have evolved into the 200-X. Last February 2, Moller climbed aboard and flew it—sort of—for the first time. He says that at the very least the flight proves that a vertical-takeoff-and-landing aircraft for commuters is technologically and economically feasible. Believers have already made down payments totaling $200,000.

Dozens of earlier visionaries have forecast "an airplane in every garage," but Moller says his vision, incorporating graphite, computers, and lightweight Wankel engines, is the first practical private saucer. The 200-X has eight engines recessed into the flat, round, 10-foot-wide fuselage. Tiny fan blades drive air down for a vertical takeoff and redirect thrust through a system of vanes for horizontal flight. Moller calculates the 200-X will cruise at 125 mph.

Bob McCafferty

The engines were originally designed to propel snowmobiles. Moller bought the technology rights and redesigned 70 parts, patenting a handful of the changes. To muffle their raucous clatter, he invented the Supertrapp motorcycle engine muffler, which grew into a $3-million-a-year business that helped fund development of the 200-X.

So far the saucer's longest trip has been by truck from Moller's corporate headquarters in Davis to his ranch 10 miles away for flight tests. Unmanned and tethered, it has climbed a modest 40 feet and advanced a few yards.

The February test was a landmark manned flight. On a broad expanse of lawn behind the company plant, Moller, nervous and expectant, strapped on a motorcycle helmet, climbed into the cockpit, and began flipping switches. A knot of investors and employees watched from a safe hundred yards away. A throbbing, muffled roar broke the silence and the seven-blade fans on each engine blurred. The saucer rose

only a foot, tipped slightly, bounced off the ground, then crept forward before reaching an altitude of three feet.

Moller claims the production version, the Merlin, will be so easy to fly ("It's basically a flying computer") that a pilot's license will not be needed. "What we've done," he explains, "is combine individually practical concepts of the past into a single practical aircraft." The Merlin will use the same technology as the prototype but bears no resemblance to a saucer—it looks more like Luke Skywalker's airborne but ground-hugging car. A Federal Aviation Administration inspector looked it over in January but will only say, "It's quite a ways from flying." Moller hopes to have it certified by the FAA by 1990.

Meanwhile, he says he's having "a bloody good time. When you love what you're doing, it isn't work." But he admits, with only a trace of exasperation, "It took me a helluva lot longer to get to this point than I planned."

—Bob McCafferty

A Piece of History

Last July, while walking along the debris-covered beach of Abaco Island in the Bahamas, Don Lowe found a large piece of the shuttle *Challenger* at his feet. For Lowe it was the find of a lifetime, but as he would discover, there are no salvage rights when it comes to *Challenger* fragments. NASA relieved him of the piece shortly after he told the agency he found it.

"I held history in my hands, but it slipped through my fingers," Lowe likes to say. He says he was "strong-armed" into surrendering the jagged section of black and white tiling that shielded the shuttle from high re-entry temperatures.

Lowe, a South Carolina physical therapist, says he has walked past miles of "space junk" on previous Bahamian vacations, but he knew he had something unique when he picked up the three- by four-foot fragment, so he strapped it to his boat when he sailed back home. After researching the fragment's origin, Lowe wrote NASA that he had recovered tiles from one of the shuttle's directional control engines, expecting a pat on the back and permission to keep the piece. That's how a NASA public affairs employee had responded in March 1987 after Lowe found a fragment that appeared to be insulation from *Challenger*'s external fuel tank.

Instead, Lowe got a call from Steven Van Meter at the Office of Security at Kennedy Space Center, asking him to turn the tiles over to NASA. Lowe reluctantly agreed, but when officials from Shaw Air Force Base arrived at his office to retrieve it, they were greeted by TV cameras and reporters. Lowe had changed his mind. "He got belligerent," says Van Meter. "I called and tried to explain that he was holding on to government property and that it wasn't simply a case of 'finders keepers.' " He told Lowe he would have to use "whatever measures necessary" to retrieve the tiles.

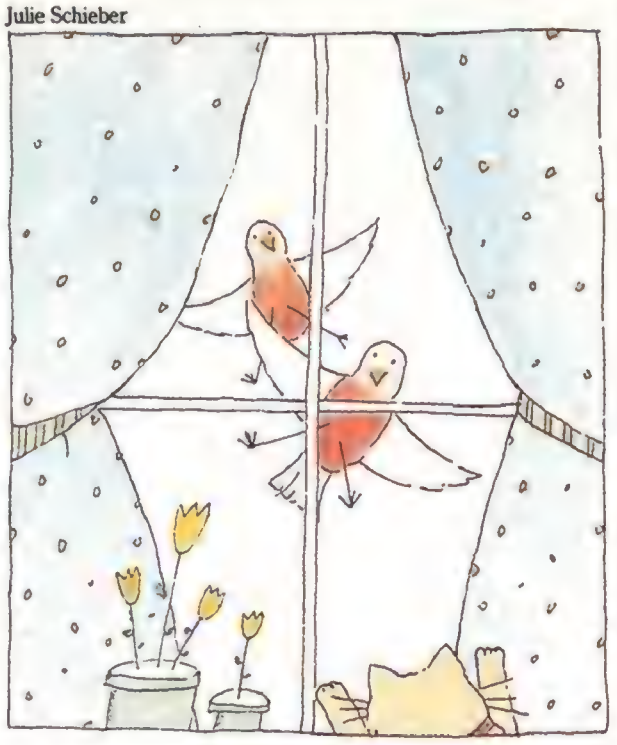
Lowe says he thought about packing up his find and making a getaway but decided not to make matters worse. "I'm a good citizen, not a criminal or a fugitive," he says. He gave in, but only after NASA promised to send a corporate jet to Florence airport—"at great expense," Van Meter adds—to pick up Lowe's fragment. The agency also invited Lowe aboard, gave him a framed poster of *Challenger,* and promised him a tour of Cape Canaveral and an invitation to the next shuttle launch. But Lowe says nothing can replace what was taken from him.

Lowe's tiles now rest with other *Challenger* debris in two Minuteman missile silos at the Cape. He says he understands why NASA would want to retrieve all remnants of the disaster. "But I still would have liked to hold on to my little piece of history," he says. "It's morbid history," responds Van Meter. "If that makes him feel good, well, okay. But the pieces belong to NASA."

In July Lowe will sail back to the Bahamas to look for more shuttle debris. "If I find something," he declares, "I'm not going to tell NASA."

—Horace Beasley

Julie Schieber



Window Pain

Every spring, robins, orioles, waxwings, and other northbound birds fly head-on into picture windows. It's not the expected case of young fliers lacking experience or male birds battling their reflections. It's simply flying under the influence.

These birds have been feeding on decaying fruits that have fermented since the fall, and it doesn't take many berries to inebriate a bird. "They instinctively know something's wrong because they're not flying real well," says Maureen O'Hara, director of Portland, Oregon's Wildlife Care Center. "Their reaction time and coordination are slowed and they can't keep their balance. They tip a lot."

Ornithologists say reports of birds falling off fenceposts and out of nests don't cease until the leftover fruit is depleted. Birds don't become addicted to the stuff but neither do they learn to steer clear of it. Says Paul Zeph of the National Audubon Society, "It's like people who get smashed on New Year's Eve."

—Steve Nieman

Yonder in the Mall

From Interstate 8 you can't quite tell just what that big red and white thing in the boutique window is. You have to get a lot closer to San Diego's Fashion Valley Mall before you realize it's a bona fide biplane.

The homebuilt Smith Miniplane hanging from the ceiling and cranked into a left bank is aimed at a hangar sign reading "Wild Blue Yonder, Fashion Valley Field, San Diego, CA. Elev. +32.5 ft. MSL." A replica of an airport control tower cab stands guard over a cash register. It looks like a hard-core aviation store, and entrepreneur James Wegge is happy to tell you why and how it became one.

First, though, you need to know the Cessna Hangar 10 story. Two years ago Cessna Aircraft Company attempted to combat a decline in aircraft sales and student pilot enrollment by bringing aviation to the marketplace. The company envisioned a chain of Hangar 10 boutiques at major shopping centers, including a Cessna 172 simulator in each store (Soundings, April/May 1986). The idea was that aviation equipment would stimulate shoppers to take flying lessons. But Cessna had to fold its two stores in Dallas and Minneapolis after only 15 months.

Despite the closings, Jim Wegge, former Marine fighter pilot, Harvard M.B.A., and owner of Flight Suits Ltd., was certain there was money to be made in peddling flying gear to the nonflying public. So he hired Jim Armstrong, Cessna's sales manager in charge of Hangar 10, and Craig

Hughes Aircraft Company designed and built a probe for the Galileo Mission, which is expected to unlock the secrets of Jupiter, providing scientists with data about the planet's atmosphere. Scheduled for launch from the Space Shuttle in late 1989, Galileo will employ a solid-fueled Inertial Upper Stage rocket, aided by gravity assists from Venus and Earth, to boost itself from the Shuttle's orbit to the giant planet. Once Galileo is within reach of outer Jupiter, the Hughes-built probe will be released into the Jovian atmosphere. During its 60-minute descent to the surface, the probe will continually broadcast scientific data back to Galileo, which will then transmit the information to Earth.

Revolutionary "smart skins" will integrate avionics and sensors directly into the skin and structure of future aircraft and space vehicles. As part of the U.S. Air Force's Project Forecast II, Hughes is working with the USAF Avionics Laboratory to develop concepts and applications for a new generation of avionics. Systems using these technologies will provide levels of performance, reliability, and fault tolerance not possible in current conventional avionics systems.

Using advanced robotics and Artificial Intelligence (AI) technologies, a U.S. Army scout car was computer-driven from a remotely located command post over a mile away. During the first-of-its-kind demonstration, the Advanced Ground Vehicle Technology program, sponsored by the Defense Advanced Research Projects Agency and the U.S. Army's Tank-Automotive Command, utilized three Hughes-built systems. The Autonomous Vision System transmitted video images of the road to computers which sent back steering, brake, and throttle commands. The AI-based Map And Planning System kept track of the vehicle at all times and displayed its location and a map of the local area on a color monitor. The system was operated day and night with Hughes thermal sensors and a complex communication link which coordinated the overall system function.

Infantry squads can maintain communications under polar conditions thanks to the Hughes AN/PRC-104 manpack radio, now the standard U.S. military field-communications system. It weighs only 14 pounds yet its lithium batteries provide enough power for voice communications at ranges of more than 1000 miles. It operates reliably at temperatures well below -50 degrees centigrade and can be used in total darkness by operators wearing the thickest mittens. Designed to meet a military specification of 2500 hours between failures, its actual record in the field far exceeds that requirement with an average of 4000 hours of fault-free operation.

Hughes is seeking experienced engineers and scientists to further develop advanced spacecraft systems and components for communications satellites. Openings are in the fields of: software, computers, and data processing systems; electrical components; microwave/RF communication systems development; on-board spacecraft electronics and control systems; satellite design, integration, propulsion, and electrical power system development; spacecraft manufacturing, systems test and evaluation; GaAs applications R&D. Send your resume to Michael Martinez, Hughes Space & Communications Group, Dept. S4, S4/A300, P.O. Box 92919, Los Angeles, CA 90009. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES
AIRCRAFT COMPANY

Subsidiary of GM Hughes Electronics

Hagen, manager of the Dallas store, and last November, less than a year after Hangar 10's going-out-of-business sale, The Wild Blue Yonder opened in San Diego. (Wegge tried to buy the Hangar 10 name but Cessna hung on to it.)

The differences between Hangar 10 and The Wild Blue Yonder reflect what Wegge thinks Cessna did wrong. "General aviation is too narrow a market," he says. "Cessna was trying to sell flight training in order to sell airplanes." But of the many people fascinated with aviation, few actually decide to become pilots. Wegge is going after the larger nonflying group. "We cater to every kind of aviation interest," he says. The store's salesmen are all pilots, and they sell aviation posters, books, key rings, teddy bears in goggles and white scarves, and leather jackets. They also sell flight computers, world aeronautical charts, logbooks, and chronographs.

Wegge's merchandising philosophy is based on sales experience he gained from Flight Suits Ltd. and Protection Plus, which sells custom helmets. He's outfitted Blue Angels, astronauts, and fighter pilots, and once sold a nonpilot in Japan $1,500 replicas of the helmets worn by Maverick and Iceman in *Top Gun*. While Wegge the F-4 jockey enjoys selling to his peers, Wegge the M.B.A. considers the Japanese buyer economically significant.

Does this mean a Wild Blue Yonder in Japan? "It's a big market," he smiles.

—Steven L. Thompson

Spaceport Hawaii

To mainlanders, Spaceport Hawaii sounds like an Elvis Presley movie. To some Hawaiians it sounds like an ecological disaster. But to state officials a launch facility sounds like good business—good enough for Hawaii's Department of Business and Economic Development to invest $500,000 in feasibility studies.

Agriculture and tourism have sustained Hawaii for decades, but with the state's pineapple, sugar, and sunshine industries smarting from international competition, Governor John Waihee is aiming higher than papayas and pineapples by rallying for an island-based space economy. The University of Hawaii already has prominent programs in astronomy, planetary science, and remote sensing, and the Big Island's Mauna Kea Observatory is one of the world's busiest.

Arthur D. Little, a Cambridge, Massachusetts consulting company, suggests that Hawaii prepare for a space economy by expanding its university programs and the observatory and by building a launch center and a space theme

Carolyn McIntyre

park. Last fall a Hawaii space facility committee endorsed Little's recommendations and suggested the state hire a "space czar . . . an individual with near-supreme authority to cut across lines of state government."

Little estimates that a sounding rocket launch complex the size of NASA's Wallops Flight Facility in Virginia—6,000 acres—would cost up to $30 million to build. An orbital launch complex could cost ten times that.

But George Mead of the Department of Business and Economic Development says state plans do not include financing a launch facility. That project will be left to customers. "The launch market is rather murky," he says, and it won't begin to clear until 1989, when commercial launch companies like Martin Marietta, McDonnell Douglas, General Dynamics, and Space Services plan to start lobbing rockets from mainland sites. Hawaiians are fiercely protective of their vast national parks, ceremonial and historic sites, fishing industry, and peace and quiet, so the state's next small step toward a spaceport is a costly environmental impact assessment, which Mead says will not commence until spaceport customers are lined up.

Large parcels of available land are almost nonexistent in Hawaii—nearly 50 percent of the state is owned by the government and 40 percent is in the hands of a few dozen families. Last February, Little recommended Palima Point, located in the Ka'u farmland district south of Hawaii Volcanoes National Park, as the prime spaceport candidate of the four sites that were under consideration.

The point is an ideal site for launches to both polar and equatorial orbits, with a launch trajectory area populated only by marine life. C. Brewer and Co. of Honolulu, which grows sugar and macadamia nuts in Ka'u and has a member of the Hawaii space facility committee as chief executive officer, has offered to donate 500 acres to a future spaceport.

Spaceport Hawaii advocates want state officials to get moving before other Pacific basin nations start reeling in launch customers. The People's Republic of China is marketing its launch services worldwide, Australia is mulling over a Queensland spaceport, and Japan is looking for a launch site to augment Tanegashima, located near a commercial fishing site and already cramped for space.

By the 1990s the Pacific basin will have a thriving space economy, but in 1988 the players are still jockeying for position. It's not yet clear if Hawaii will get the inside track.

—Linda Billings

Waiter, There's a Fly in My Telescope

Last summer astronomers at the Royal Greenwich Observatory in Herstmonceaux, England, were in search of a spider. According to observatory spokesman Charles Parker, a fly had gotten into the 26-inch refracting telescope and had broken the calibrating cross-hairs, which are formed of strands of spider web. Staffers were scratching their heads trying to determine which type of spider had provided the cross-hairs and how to obtain another and coax it into producing a new set. "I'm told the spider has to be kept in a box to quiet it down before it weaves its thread," said Parker. "If the spider is agitated the thread is not uniform. It has little blobs in it, and that is the last thing we want."

Eventually someone in the observatory's electronics department improvised a man-made web of nylon filament from electrical cable wrapping.

"It's twice as thick as a spider web but perfectly adequate given the use of the telescope," says public relations officer John Alexander. "It takes some skill to get a spider web—you have to get a frame, have the spider make a web from one side to the other, then shellac it into place. It's not that worthy a telescope to put that effort into it. In fact, we're moving to Cambridge in 1990 and we won't be taking it with us."

—Michael Rozek

Lying Down on the Job

One morning last December Richard Fitzpatrick was waiting in line at the teller's window of a Houston bank—on a stretcher. He was sure the other customers thought that only deep financial trouble could reduce him to doing his banking from a gurney. But his financial and physical conditions were both just fine. For Fitzpatrick it was simply another day on the job—one of the weirdest he's ever held.

Fitzpatrick, a 45-year-old social worker, spent the last four months of 1987 lounging in a hospital bed, watching videos, and being waited on hand and foot, all for the space program. Paid $187.60 a week, he became, basically, a professional couch potato.

As NASA gears up for long-term spaceflights, it is investigating the medical problems resulting from lengthy stays in a low-gravity environment. One of the difficulties astronauts have encountered is a loss of bone mass. By analyzing the changes Fitzpatrick underwent during protracted bed rest, the agency hopes to learn how to slow down bone disintegration, both in space and on Earth.

For Fitzpatrick, the experience was a welcome if numbing interlude. After participating in a shorter but similar test for NASA, he volunteered for the long-term experiment to help with the space effort and get some rest. He used the time to earn a certificate in substance abuse counseling, catch up on his reading, and study Spanish. But the experience had its drawbacks: sitting up was limited to propping himself on an elbow, and everything he ingested and excreted was measured. After each meal, which was carefully prepared to have a certain calcium content, Fitzpatrick was required to rinse each container with water and then drink the contents.

Fitzpatrick's sense of humor helped him cope with the continual tests, identical meals, and daily irritations of hospital life. He also grew a ponytail. "Up in space," he says, "they'd cut it. Maybe recycle it into toothpaste."

When he first returned to the vertical world—"reambulation," the physicians call it—Fitzpatrick had a bout of dizziness, just as astronauts fresh out of a spacecraft do. His first three weeks of adjusting to normal orientation were spent under doctors' scrutiny as part of the NASA study, and an extra week was tacked on to take more measurements. Fitzpatrick will be on call through the rest of this year for further testing, a more thorough follow-up than astronauts have had.

Over the next two years NASA will repeat similar tests with other subjects to compile a statistical database on the effects of inactivity. Results will be available in the 1990s. As with most of its projects, the agency expects spin-offs that will benefit society—in particular, ideas for treating

osteoporosis.

Fitzpatrick says he is happy to have made a contribution. But, adds the space spud, "NASA did all the work. All I did was process it."

—Byron Harris

Update

The Boeing 707 evicted from the Franklin Institute in Philadelphia (Soundings, February/March 1988) failed to find a new home. "We'll save the cockpit section for an exhibit but we'll have to scrap the rest for parts," says curator John McDevitt. "None of the candidates had—in our opinion—sufficient funds to care for it properly."

Astronomers using a supersensitive infrared detector ("Seeing Red," December 1987/January 1988) have found what appear to be clouds of primordial gas and dust on the verge of becoming stars and galaxies 17 billion light-years from Earth—at the edge of the observable universe. A team of University of Arizona astronomers made the discovery with an infrared array that contains more than 4,000 detectors on a one-eighth-inch chip. These primeval galaxies may be the oldest objects in the universe, even older than a possible quasar detected last December.

The registration number of Amelia Earhart's Lockheed Electra (Above & Beyond, February/March 1988) has been retired from Federal Aviation Administration service. Muriel Earhart Morrissey made the request to honor the disappearance of her sister during a round-the-world flight 51 years ago. The FAA found that U.S. registration number N16020 had been assigned to Continental Airlines, which agreed to relinquish the number. "We'd been holding it for a couple of years," says Continental spokesman Jim Brigance, "but it wasn't assigned to any aircraft."

Eastern's Air Line Pilots union has sent its 3,600 members a videotape of retired Navy pilot Charlie Plumb talking about the six years he spent as a prisoner of war in Vietnam. Union spokesman J.B. Stokes hopes Eastern pilots "will benefit from his experience and how he overcame it." The airline has cut salaries and laid off employees to reduce costs. "Morale is at an all-time low," Stokes says, "but the pilots I fly with tell me it's a darn good tape and they're glad we sent it."

—Patricia Trenner

It was October 14, 1947. Air Force Captain Charles E. "Chuck" Yeager was about to become the first human being to fly faster than the speed of sound. It happened 43,000 feet over the Mohave desert as Yeager piloted the highly classified Bell X-1 to its place in history.

Revell's new 1/32 scale X-1 is destined to be the aircraft kit of the year among modelers and aviation enthusiasts alike.

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October 14, 1947

Chuck Yeager

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Anniversaries . . .

1514
April 26 Nicolaus Copernicus makes his first observation of Saturn. The sixth planet from the sun appeared to be aligned with the stars that make up the head of the constellation Scorpius.

Jean-Leon Huens

Copernicus' discoveries refuted Ptolemy's theory of an Earth-centered universe.

1845
April 2 French physicists Jean Foucault and Armand Fizeau take the first clear photograph of the sun. They used the daguerreotype process, in which an image is made on a chemically sensitized silver-coated copper plate.

1916
April 15 Washington residents are startled by a mock air raid over the nation's capital. Hundreds of cars and pedestrians jammed the streets as firework "bombs" exploded in the night sky. The perpetrator was De Lloyd Thompson, who in his Day biplane swooped over monuments and government buildings dropping wing-mounted bombs. Concerned about zeppelin raids on European cities, Thompson wanted to demonstrate the vulnerability of U.S. cities to aerial attack. "I could have blown the White House and Capitol off the map had I been armed with the most deadly explosives," he warned afterwards. *The New York Times* reported that Army officials, who had been advised of the raid beforehand, made a "good-humored effort" to track down the aviator in response to a flurry of inquiries.

May 4 Katherine Stinson gives a brief aerobatic demonstration at night over New York City. Stinson had planned a daylight show, but her biplane arrived too late at the Sheepshead Bay Speedway to be assembled before nightfall. Rather than disappoint her audience, she gamely took off, ascended to 3,000 feet, and made two loops, which were traced by lights on the airplane. Her landing on the racetrack was illuminated by red flares.

1927
May 6 A pilot in an Army airplane engages the citizens of Weirton, West Virginia, in a game of aerial chicken. Pedestrians, terrified by the low-flying aircraft, ran to their houses only to rush back outside as the presumably crazed or drunken aviator dove at their homes. Teachers dismissed students when the airplane repeatedly zoomed past the school's windows; as the children poured out of the building, the airplane took off after them. The pilot was never identified.

1945
May 1 Hundreds of Eighth Air Force B-17s take off from England to drop more than 700 tons of food over German-occupied Holland. Since food shortages and severe flooding had caused massive starvation among the Dutch, the Germans approved the mercy mission and agreed not to shoot down the bombers if they stayed on specified routes. Over the next week, five more "Chow Hound" missions were completed. Dutch citizens laid out messages for the fliers using cloth, rocks, flowers, and pieces of wood.

NASM

Dutch citizens laid out messages on the ground to signal their gratitude . . .

1959
April 10 Northrop's prototype YT-38, which would become the Air Force's first supersonic trainer, makes its first flight from Edwards Air Force Base in California. A *Northrop News* editorial announced that the company's latest aircraft would "mother a new generation of flying men . . . . She will hold her own and more in that great high blue classroom where young American pilots will learn the three Rs of space."

The Coke bottle shape of its fuselage helped propel the T-38 to Mach 1.2.

NASM

NASM

. . . for the tons of bacon, baked beans, cereal, and milk dropped by U.S. B-17s.

NASA

Primates were used for research on the effects of spaceflight on humans.

May 28 A squirrel monkey, Miss Baker, and a rhesus monkey, Able, become the United States' first primates to be successfully launched into and recovered from space. Their 15-minute flight aboard a Jupiter rocket was part of an Army-NASA study of the physiological effects of space on primates. Able later died from a reaction to anesthesia, but Miss Baker appeared on numerous talk shows and received up to 50 letters a week from schoolchildren. She retired to the Alabama Space and Rocket Center and was a tourist attraction until her death in 1984.

1963

May 7 The term "via satellite" sees widespread usage with the launching of AT&T's communications satellite Telstar II. On its fourth orbit it transmitted test patterns and a video of AT&T executives from a station in Andover, Maine, to cities in England and France. During its first year, Telstar II broadcast Gordon Cooper's Mercury 9 flight, the funeral of Pope John XXIII, and the Winter Olympics in Innsbruck, Austria.

AT&T's Telstar satellites were powered by 3,600 solar cells.

NASA

1967

April 24 Soviet cosmonaut Vladimir Komarov is the first person to die during a spaceflight. On April 23 he was launched to test Soyuz 1, a spacecraft designed to travel to the moon. Soon after reaching orbit, Komarov encountered problems: occasional tumbling progressed to uncontrollable spinning. Flight controllers had Komarov's wife rushed to mission control when they feared that a successful re-entry would be impossible. Unable to stabilize the spacecraft, Komarov bid his wife farewell. The descent parachute deployed only partially on re-entry, and Soyuz 1 crashed to earth at 350 mph.

Sovfoto

Vladimir Komarov became a Soviet hero after his death aboard Soyuz 1.

1971

April 19 Salyut 1, a building block for the world's first space station, is launched from Tyuratam, a Soviet launch complex. The space station core had docking ports for four manned Soyuz spacecraft. The first docking occurred a few days later, with Soyuz 10 and cosmonauts Vladimir Shatalov, Alexei Yeliseyev, and Nikolai Rukavishnikov. Yeliseyev described Salyut 1 as "beautiful on Earth, but much more so in space, because its bright colors are even brighter and richer there."

U.S. Geological Survey

Ash from Mount St. Helens closed some airports for as long as two weeks.

1980
May 18 At 8:32 a.m. Mount St. Helens erupts, closing nearby airports for up to two weeks and producing the worst volcanic disaster in U.S. history. The catastrophe started with a 5.1-magnitude earthquake, which caused the north side of the summit to collapse. Geologist Keith Stoffel witnessed the unexpected avalanche from a light airplane: "The nature of the movement was eerie . . . . I was amazed and excited with the realization that we were watching this landslide of unbelievable proportions." The sudden collapse released pressurized steam and gas, which exploded in a blast that devastated 230 square miles. Hot ash from the explosion, which reached an altitude of 12 miles, killed about 60 people, darkened the skies of Yakima and Spokane, and fouled aircraft engines.

. . . and Events

Through April 11
"Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

Through July 17
"Into the Sunlit Splendor: The Aviation Art of William S. Phillips," Smithsonian Traveling Exhibition. At Airmen Memorial Museum, Suitland, MD, (301) 899-3500.

April 10–16
Sun 'n' Fun 1988 14th annual fly-in. Sponsored by Experimental Aircraft Association. At Lakeland Municipal Airport, Lakeland, FL, (813) 644-2945.

April 12–16
National Intercollegiate Flying Association's 40th Annual Safety and Flight Evaluation Conference. Precision flight teams from 24 U.S. colleges compete in flight and ground events such as power-off landings and aircraft recognition tests. At Northeast Louisiana University, Monroe, LA, (318) 342-2055.

April 16
"Into the Teeth of the Tiger," lecture by National Air and Space Museum deputy director Donald Lopez on his combat experience in China during World War II. At Wichita Art Museum, Wichita, KS. Smithsonian National Associates, (202) 357-1350.

April 22
Lyrid meteor shower, two to three hours before sunrise.*

April 23
Bay Area Airline Historical Society Convention. Buy, sell, and trade airline collectibles. At Sheraton Hotel-San Francisco Airport, Burlingame, CA, (415) 574-8111.

Astronomy Day Open House. Telescopic viewings of the sun, U.S. Navy Band concert, and tours of the grounds, including the world's most accurate atomic clock. At U.S. Naval Observatory, Washington, DC, (202) 653-1543.

April 23–May 1
CSR Hinkler Bicentennial Air Race. A nine-day race along the Queensland coast and through the Outback. Entries include piston-engine, antique, airline, and military aircraft. Write to The Secretary, Box 18 GPO, Brisbane 4001, Australia, or call (07) 228-4630.

Pioneer aviator Lores Bonney, 90, announced Australia's bicentennial air race.

Terry Gwynn-Jones

April 24
Kitefest. Kalamazoo County Parks Department. Includes kite flying competitions and a workshop for children. At River Oaks Park, Kalamazoo, MI, (616) 383-8778.

April 30–July 17
"Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Science Place I, Dallas, TX, (214) 428-5555.

May 13–22
Air/Space America '88 International Aerospace Trade Exposition and Air Show. Concorde rides, antique and military aircraft, and air races. At Brown Field, San Diego, CA, (619) 294-8808.

May 21
Department of Defense Joint Services Open House. Military aircraft demonstrations, walk-through aircraft displays, and performances by the Blue Angels and Golden Knights. At Andrews Air Force Base, Camp Springs, MD, (301) 568-5995.

May 21 & 22
Space Expo '88. The Space Frontiers Society of Long Island. Displays include Neil Armstrong's backup spacesuit, a moon rock returned by Apollo 17, inflatable planetarium, and model rocket launches. At Cradle of Aviation Museum, Garden City, NY, (516) 222-1190.

May 29
West Texas Wing/Confederate Air Force 11th Annual Airshow. More than 100 warbirds are expected to attend. At Stephens County Airport, Breckenridge, TX, (817) 559-9129.

Mir Watch Hotline
The Soviet space station Mir orbits Earth every 90 minutes. For viewing times, call National Space Society, (202) 546-6010, 9:30 a.m. to 4:30 p.m. EST.

**Call the Smithsonian's Earth and Space Report at (202) 357-2000 for recorded information on astronomical events.*

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Diane Tedeschi

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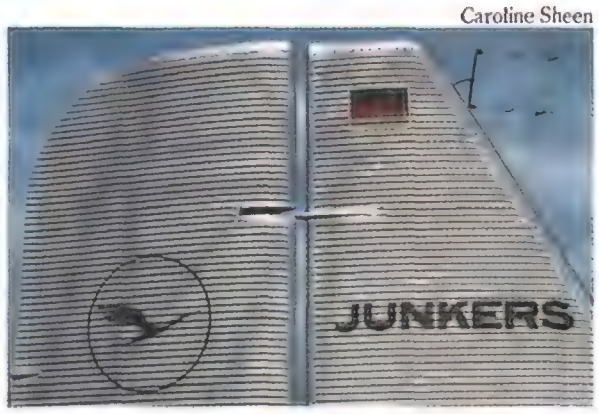
Auntie Comes to Stay

The ungainly metal airplane was a strange sight, and the famous German World War I pilot regarded it with suspicion. "Are you so tired of life, then," he reportedly asked a friend at its controls, "that you are flying a machine without bracing wires?"

The machine in question was the Junkers-J 1, the world's first all-metal airplane. It may have looked odd, but when the one-ton beast first flew in 1915, aviation took a big step away from wood-wire-and-cloth aircraft to more durable metal machines.

Junkers, a German company, continued to revolutionize aviation as it began to experiment with lightening all-metal construction. The corrugated metal the company developed for its aircraft eventually became Junkers' most recognizable trademark, and the approach was later borrowed by builders of such airplanes as the Ford Tri-Motor.

Caroline Sheen



Strong but light, Junkers' corrugated skins popularized all-metal airplanes.

One of the best known Junkers was a corrugated bird: the Ju 52/3m, which first flew in April 1932. The airplane was 62 feet long with a wingspan of nearly 96 feet—roughly the size of its U.S. equivalent, the DC-3. Boxy, blunt-nosed, with rippled skin and low-slung wings, the Ju 52/3m wasn't glamorous. But it was reliable and rapidly became the best known and most widely used European transport aircraft of its time.

"It wasn't all that fast; it flew about 130

Caroline Sheen

The sturdy Ju 52/3m was the pride of Lufthansa's fleet in the 1930s and '40s.

miles per hour," says the National Air and Space Museum's curator of air transport, Ron Davies. "But it was well loved by the pilots and the people who traveled in it."

Between 1932 and 1952, Junkers and its subcontractors built almost 5,000 Ju 52/3ms, changing the airplane very little in those two decades—a tribute to its basic design. "Maybe the engines are very slightly more refined," Davies says, "but the basic design was just the same: they never changed it."

By 1940, the height of the airplane's popularity, the German airline Lufthansa had 80 in service—the most airplanes of a single type in operation with any airline in the world at the time. The reliable Ju 52/3m quickly earned the affection of German pilots who gave it the nickname of *Tante* ("Auntie") *Ju.*

During World War II, as it was enlisted to transport troops and carry supplies, *Tante Ju*'s numbers began declining rapidly. An armada of 493 carried troops to Germany's last big airborne assault of the war, the invasion of Crete on May 20, 1941. Some 170 Junkers and thousands of troops were lost in the fray.

A little over a year ago, Ron Davies began searching for a surviving Ju 52/3m to add to the Museum's collection. "It's important that we have a representative collection of the world's commercial airplanes from the very earliest days to the present," he says. "At the moment, the airliners we've got in this building are representative of only one decade of one country; that is, 1926 to 1936, in the United States."

His search first led him to the Swiss air force, known to have three Ju 52/3ms still flying, but the Swiss didn't want to part with any. Another lead proved to be little more than a pile of scrap metal in a German field. Finally, he found one: a British company that supplied the movie industry with props had a nonflying 1950 model it was willing to part with—for $150,000.

Davies persuaded Lufthansa, which had relied so heavily on the Ju 52/3m 50 years ago, to purchase the Junkers and donate it to the Museum. The airplane was disassembled, shipped from Southampton, England, to Baltimore, Maryland, and then trucked to Virginia's Dulles International Airport. There, under contract to Lufthansa, Page Avjet cleaned, reassembled, and repainted the airplane, using the colors the Junkers bore when entering service with Lufthansa.

Newly agleam and unexpectedly dashing against an overcast sky, the airplane was formally presented to the Museum last November 19, while admiring German pilots and aviation writers waited patiently for an opportunity to sit in the cockpit.

Months after its presentation to the Museum, however, the Ju 52/3m was still resting outside the Page facility. With severely limited space, the Museum was having trouble finding a place for its prize. To help it weather the winter, staff members recently covered its three engines, door openings, windshield, and other sensitive areas with heavy-duty plastic shrink film. Sometime this spring, the Junkers is expected to take up residence in a warehouse being constructed at Dulles to shelter the space shuttle *Enterprise* and several other large acquisitions. Davies hopes Museum space will eventually permit its exhibition.

"I consider this to be a very valuable addition to our collection of airplanes," Davies says. "Of course, if you ask any airline or air transport specialist to pick out the 12 most significant airplanes of all time, you would receive as many different lists as people you ask. But there would be many common names there—among them the Junkers."

The Museum's new acquisition is one of the few scattered Ju 52/3ms surviving. However, one survey of historic European aircraft surmised that portions of many of the sturdy airplanes, having likely been sacrificed "to provide some remarkably strong sheds and chicken houses," may still be in service of sorts.

—Karen Jensen, Associate Editor

"We the space progeny of Earthkind . . ."

When America's founding fathers framed the U.S. Constitution, they failed to foresee many future developments. Not surprisingly, one was the prospect of Americans living in space.

Do Americans in space have the same rights as those on Earth? And what form should these rights take in the un-Earthly context of a space-based society? After heated meetings at the Museum in late 1986 and 1987, a document taking a step toward answering some of these questions has emerged. (See "Law of the Next Frontier," August/September 1987.)

The idea of framing principles for living in space grew out of discussions three years ago on how the Museum could celebrate the Constitution's bicentennial. The Museum joined forces with Boston University's Center for Democracy to co-sponsor the effort.

A planning committee that included Associate U.S. Supreme Court Justice William J. Brennan Jr., Senator John H. Glenn, and Walter Cronkite invited about 40 individuals to the conferences. Reflecting the complexities of life in space, they came from the fields of engineering, biomedicine, law, economics, sociology, psychology, bioethics, and philosophy, among others. Like participants of the gathering in Philadelphia 200 years earlier, most arrived with significantly different levels of expectations and parochial interests to protect.

Initially, the possibility of U.S. chauvinism arising caused discomfort among many participants. David C. Webb, chairman of the University of North Dakota's space studies department, asserted that "as a native-born Irishman, I would question the right of this present group, including myself, to lay down any first principles for the settlement of space. I am very, very sensitive to colonial overtures, and I sense many of them in this room." David Challinor, conference co-chairman and the Smithsonian's assistant secretary for research at the time, countered by emphasizing that "when people of goodwill assemble, useful thoughts can indeed develop."

The document that eventually emerged from the conferences took the form of a petition aimed at helping authorities focus on the fundamental rights and freedoms of Americans living in space. While holding that the values embodied in the Constitution should apply to all individuals in space societies under U.S. jurisdiction, the declaration adds such rights as the freedom to travel to, in, and from outer space and the right of space society inhabitants to a governance that reflects their will. The declaration also allows for other rights yet to emerge from the experience of living in space.

Not intended to be a finished document, the declaration—and the process of formulating it—were also intended as templates for further study. One such possibility is the incorporation of a study of the declaration into the curriculum of Project STAR (Science Teaching through its Astronomical Roots), a program for high school students sponsored by the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

In the future, the declaration could well become irrelevant as space societies and cultures evolve. But conference participants hope that, like the U.S. Constitution, it will continue to remain vital, establishing explicit, inalienable rights for our sons and daughters living and working in space.

—George S. Robinson, Senior Consultant, Governance in Space Project

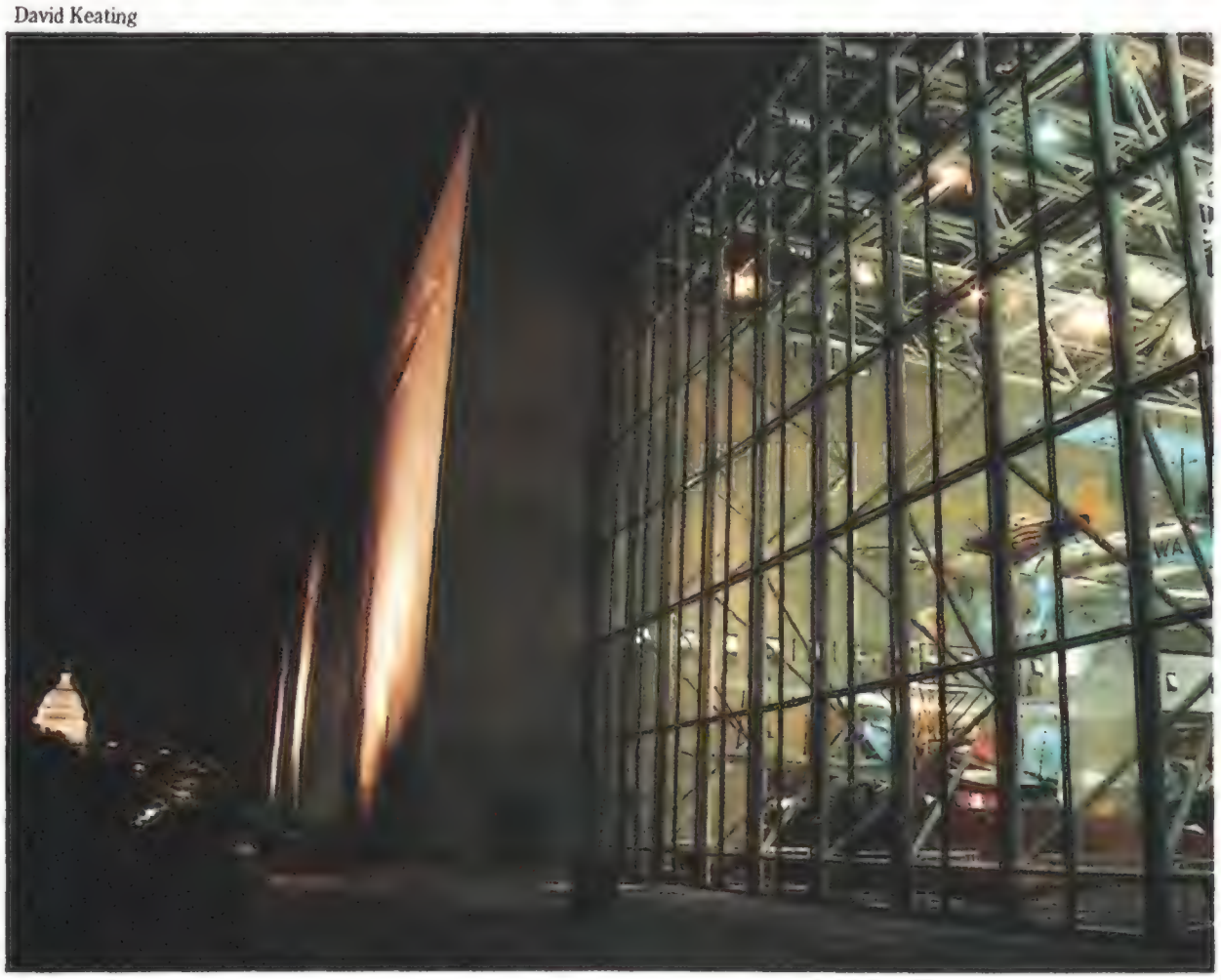
Photo Finish

The Museum's Douglas D-558-2 Skyrocket is now suspended in silent flight outside the Langley Theater. But in 1953 it became the first airplane to exceed Mach 2. In Frank Cappello's photograph "The Envelope," the rocket-propelled craft appears to fly again. First-prize winner in the "Capturing the Collection" category, the photograph is one of about 40 from the Museum's "Focus on Flight" photography contest, which inspired fresh views of the Museum, its collection, and its visitors. The photographs are on display in the Pioneers of Flight Gallery through July 31.

Frank Cappello

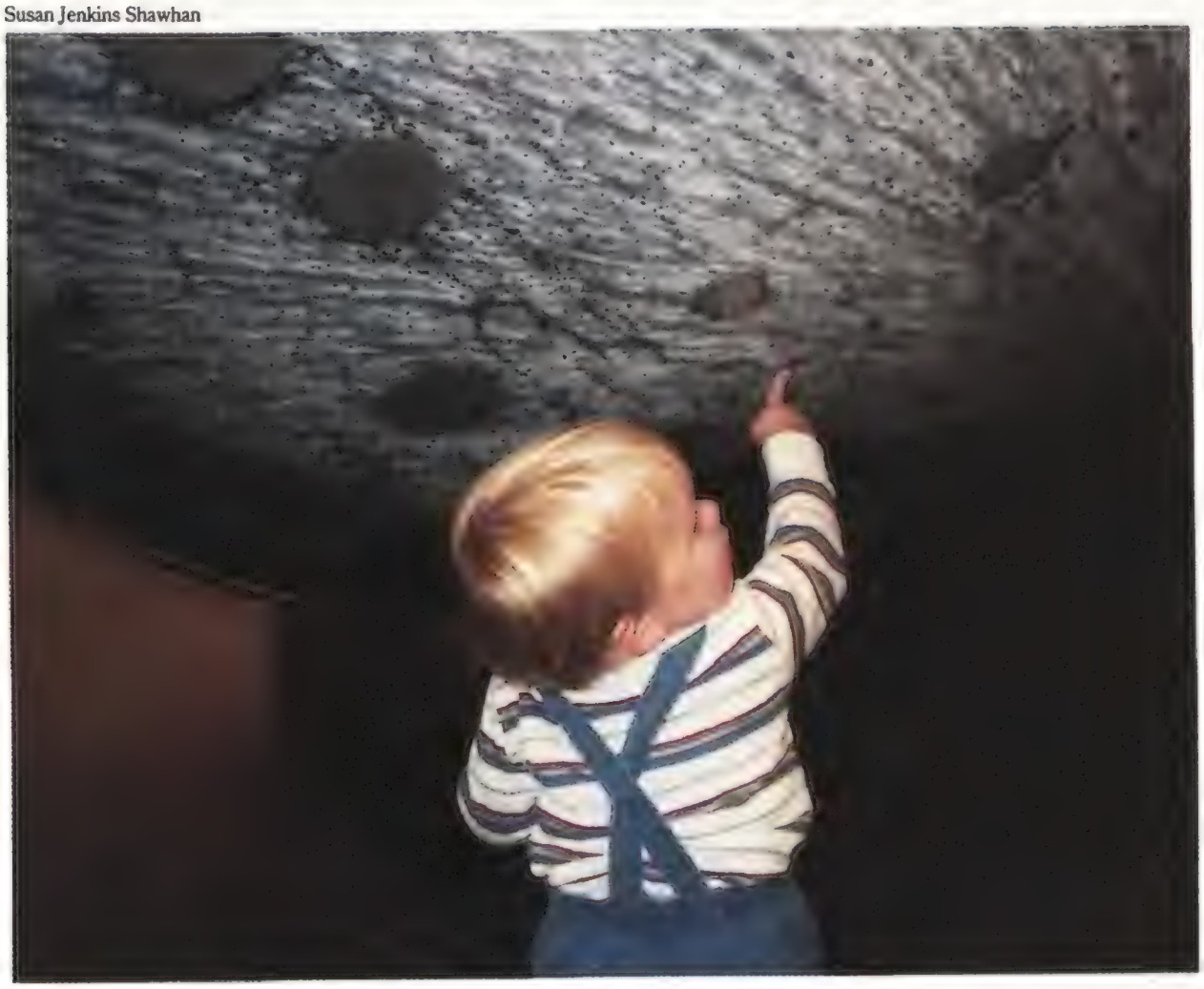
"The Envelope" won in the "Capturing the Collection" category.

David Keating



David Keating's "Night Visions" took first prize in "Form and Function."

Susan Jenkins Shawhan



"Our Future Touches Our Past" topped the "People Plus" category.

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Tuesdays, March 29–May 10 Investigating Modern Astronomy Lecture Series: weekly lectures presenting basic concepts of modern astronomy. Einstein Planetarium, 7:30 p.m.

April 2 Monthly Sky Lecture: "Same Sky, Different Story." Ron Doel, Space Science and Exploration Department, NASM. Einstein Planetarium, 9:30 a.m.

April 14 General Electric Aviation Lecture: "Tale of the Komet." Rudy Opitz, former Messerschmitt test pilot and Me 163 squadron commander. Langley Theater, 7:30 p.m.

April 20 Exploring Space Lecture: "The Infrared Sky." Nancy Boggess, NASA-Goddard Space Flight Center. Einstein Planetarium, 7:30 p.m.

April 23–24 Annual open house, Paul E. Garber Preservation, Restoration and Storage Facility, Suitland, MD. See the Facility's 140-plus aircraft, watch restoration technicians at work, and participate in many air- and space-related activities. 10 a.m. to 3 p.m.

April 28 Exhibit opening: "Horizons: The Drawings and Paintings of Robert Taylor." In the Flight in the Arts Gallery through April 28, 1989.

April 29 Seminar: "Blacks in Aviation: Three Historic Films." An all-day seminar focusing on the achievements of black aviators as depicted in the films *Black Wings* (1935), *Wings for This Man* (1944), and *Flying Aces* (1927). Langley Theater, 12 noon.

May 7 Monthly Sky Lecture: "Space Telescope Update." Ray Villard, Space Telescope Institute. Einstein Planetarium, 9:30 a.m.

May 18 Exploring Space Lecture: "An Ultraviolet View." Andrea Dupree, Smithsonian Astrophysical Observatory. Einstein Planetarium, 7:30 p.m.

May 19 Charles A. Lindbergh Memorial Lecture: "The Hawker Harrier." John W. Fozard, Charles A. Lindbergh Chair of Aerospace History, NASM. Langley Theater, 8 p.m.

Burning Ambitions

When the Soviets launched Sputnik in 1957, Perry James and I figured we ought to put something in orbit pretty quickly. *Some* American had to, and as 11-year-olds, we weren't convinced that the government would be the ones to do it. We lived near Huntsville, Alabama, where my father was a mathematician at the Army Ballistic Missile Agency, so the crisis was a family affair.

Perry and I duly trotted over to the Athens State College library and looked up Rockets. The *Encyclopaedia Britannica* in those days offered more information on munitions than parents—and, fortunately, children—suspected. We had followed the recipe for thermite, for example, using aluminum powder and iron oxide liberated from the college chemistry laboratory, and burned the neatest hole through Mrs. James' best frying pan. An orbital rocket should be no problem—we figured it would take about a week.

Sure enough, the *Britannica* explained Hale, Congreve, Goddard, and the rest of the gang, and concluded—*aha!*—that zinc and sulfur made a serviceable rocket fuel. The precise proportions weren't given, but Athens College had plenty of chemicals and invariably replaced anything we exhausted in our pioneering efforts.

For a couple of mornings Perry and I trooped off to the stagnant pond behind the science building. The pond, which served as our laboratory, was a sunny home for frogs, bugs, and rich green slime to examine with microscopes. We mixed zinc and sulfur in little piles of varying proportions and fired them off with lucifer matches. The pile that made the loudest *whoosh* we judged the most efficacious mixture. We added a touch of potassium nitrate and reagent-grade charcoal, thinking that a slight gunpowder effect might give it the appropriate amount of *oomph*. Then potassium chlorate, a versatile oxidizer that made any incendiary mess burn faster, and—was it potassium permanganate and manganese dioxide?—I've forgotten most of my propellant theories. I do remember that whatever we used, any was too much.

The next step was finding a suitable rocket body. The college, with admirable forethought, had bought a bunch of army-surplus radio antennas. With less forethought, they had been put in a shed with a loose ventilator on the roof, the diameter of which was greater than that of an 11-year-old. We appropriated one of the fat aluminum antennas, painted an official government-surplus black, for a rocket body. We sealed one end with a screw-on plug that came with the antenna.

We then bought several feet of dynamite fuse at the hardware store. In Alabama, dynamite was used to blow up stumps, Tennessee Valley limestone, and perhaps Yankees. The fuse itself was considered harmless, but it would burn underwater most impressively. (Exploiting this capability, Perry and I once persuaded a bunch of kids that a volcano was erupting from the depths of the pond, but that's another story.)

On launch day we sauntered over to the pond in sneakers and jeans—the early days of space exploration were more casual than today—and stuffed the antenna with fuel. Then we poked in a piece of fuse and pointed the assembly in what seemed the proper launch direction. Using Kentucky windage as the sole guidance may evoke sneers from today's engineers, but in a single week Perry and I launched as much as the government did in the 18 months following Sputnik. If those agencies could have matched our development cycle we'd have Levittowns on Betelgeuse by now.

William L. Brown

The fuse burned slowly as dragonflies flitted and methane bubbles struggled through the slime. Then: nothing. We crept out from behind the hillock that served as a launch bunker. The fuel hadn't lit. Nuts. We tried another length of fuse. No go. We built a little fire with paper and twigs around the business end and ran like the dickens. Nothing. I pulled out a lucifer match, said "Oh hell," and shoved the burning head into our spacecraft.

A tremendous *whoosh* followed and the rocket disappeared. I don't know if it achieved orbit—it may have—but at any rate, we never found it. I was preoccupied with streaking toward home, hollering, favoring my blackened hand. A word of wisdom for the folks at the Cape: if it doesn't light and you're considering applying a match, make sure the fuel doesn't contain sulfur.

An hour later, when my parents got home, I was locked in the bathroom soaking my hand in cold water. Realizing that I couldn't stay there forever, I emerged and said, "Well, Pop, I guess I had, you know, a little accident . . . ." The family doctor repaired the damage with antibiotic ointment and a bandage, and my father suggested that I restrict my scientific enthusiasm to less explosive pursuits.

Over the next three years, as I watched U.S. rockets topple majestically on their stands, occasionally lighting the earth with glory but achieving no increase in altitude, I would murmur, "Just add a little potassium chlorate and that rascal will zing." But they didn't listen.

—Fred Reed

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Sea Serpents and Steel Forests

February 1941 wasn't the ideal time to be sightseeing over the North Sea. The temperature was below zero, and the falling barometric pressure and gathering clouds meant that the latest in a series of storms that had left much of the British Isles snowbound was swirling down from the Arctic.

Several hundred yards ahead of my Spitfire was another, its Royal Air Force roundels momentarily illuminated by a hazy shaft of sunlight as it banked over the British freighter leading the convoy below us. Another Spit turned above the wake of the last ship. We were at 900 feet, just beneath the clouds, and had been circling the ships for a half-hour. It would be another hour before we were relieved and on our way back to North Weald, an RAF station northeast of London.

Each time I followed the leader through a turn, I looked down on towering whitecaps that seemed to reach for my wingtip. The gray clouds grew thicker. Soon it would be difficult to distinguish sky from sea.

I was an American volunteer serving in the 121 "Eagle" Squadron, one of three that served with the RAF from 1940 to 1942. Nearly 250 Americans flew as Eagles; they were later transferred to the U.S. Eighth Air Force and became the highest scoring fighter group in the Army Air Forces. Half of them died during the war.

Flying convoy patrol, even in the glamorous Spitfire, could be deadly dull: straight and level for a few seconds, bank and turn, fly in the opposite direction, bank and turn; repeat these slow, effortless circuits forever. But the mind took more comfort in such mindless maneuvers than in contemplating the chances of survival in the icy sea. If your engine failed too far off land, you faced two grim choices: bail out, knowing that even with sufficient altitude for your parachute to open you would probably perish in the wind-whipped sea before help could arrive; or ride the airplane down to what should be a quick and merciful end. It seems almost sacrilegious to say anything derogatory about the Spitfire, but it did have one shortcoming—it dove like a cormorant on contact with the water. The problem was the large airscoop under the fuselage. It would either catch the top of a wave and flip the airplane on its back or funnel enough water into the fuselage to cause an immediate dive.

I don't know what I was thinking about when the explosion occurred. I had just turned upwind, scanned the instrument panel, and was staring at the sea when a gigantic geyser erupted between me and the nearest freighter. For a moment I thought a sea serpent was surfacing. Then I caught a glimpse of a German Ju-88 as it ducked back into the clouds, and I understood. The Junkers, in search of the convoy, had come down through the overcast above the leading freighter, and its pilot, seeing the Spitfires and realizing he had no time for a bombing run, had jettisoned his bombs into the sea to lighten up for a getaway.

I reacted instinctively, slamming the throttle forward and arming machine guns and cannons. I made a steep turn and headed out to sea, hoping to spot him through a break in the clouds, but it was futile. I flew 30 miles without finding so much as a seagull. I decided to turn back toward the convoy.

The other Spitfires were still circling. I reduced speed, switched guns and cannons back to *Safe,* and scanned my instruments as I slipped into line. Engine temperature was high, but I had just been flying on overboost—extra power—so I wasn't greatly concerned.

It wasn't until I had completed one circuit and was on the seaward side of the convoy that I noticed that the engine hadn't cooled down—the needle was in the red and still climbing. I keyed the microphone switch. "Blue One, this is Blue Two. I have coolant trouble. Needle is in the red. Afraid I'll have to abort. Over."

"Understand, Blue Two." The soft Texas drawl was distorted by crackling static. "Better not try to make base. Martlesham is the nearest field. Good luck, Griff."

Looking at the distant shore and the freighters I had to fly around, I knew I could use all the luck I could get. If the engine temperature continued to rise, a piston could seize or a fuel line could rupture and start a fire.

Whichever happened, I didn't want it to occur over water. Ignoring the fact that I would be an easy target for the ship's nervous young gunners, who tended to fire at friend and foe alike, I wheeled over and cut through the convoy. I could see the faces of the crew huddled around the anti-aircraft gun. It swiveled to follow me but the gunner held his fire.

Spotting huge chunks of ice tossed by angry frothing whitecaps, I had an almost uncontrollable urge to slam the throttle forward and hightail it to land. But that would mean an even hotter engine. I throttled back to just above stall speed.

Once over the beach, the primary decision—what to do if the engine failed now—was an easy one. The ice-covered dunes were a forest of steel, concrete, and barbed-wire emplacements designed to repel landing craft and tanks. The possibility of surviving a crash-landing or a bailout wasn't worth considering. It would be better to turn back to sea—at least there I had no chance of being impaled on a rusty post.

The wide swamp beyond the beach wasn't much more appealing—its saltwater channels would destroy the Spitfire as surely as the sea would, and the thought of bailing out and plunging into the quicksand lining the tidal pools was equally uncomfortable.

But before I could agonize further I was past the swamp and over solid ground. I breathed a sigh of relief as I checked the temperature gauge. The needle was almost at redline, but it didn't seem to be climbing. Still, this was small consolation: I didn't know which point on the gauge indicated that the heat was great enough to rupture a fuel line.

But the luck wished on me by my Texas friend came through. The last ten miles to Martlesham were an anticlimax. The storm held off, no smoke streamed from the engine compartment, and the engine purred smoothly.

Phil Jordan

I heaved a sigh of relief upon spotting the field. "Hello Martlesham Control. This is North Weald aircraft. Request permission to make an emergency landing. Over."

"Permission denied, North Weald aircraft. I repeat, permission denied. Field is closed. Over."

Permission denied? What in hell? I was riding a bomb that could explode any moment, and he was telling me to hunt up another field!

The runway was an ice rink bordered by huge piles of snow—not the ideal place to land, but then neither were the bordering fields, where deep snow could be concealing stumps and boulders that would tear an airplane apart.

"Martlesham Control, this is North Weald aircraft. I'm coming in. Over and out." I flipped the radio switch to *Off* before he could answer, lowered gear and flaps, and turned my attention to landing.

The small Spitfire was so beautifully designed that it appeared fragile. But the only other machine that could have withstood the battering that airplane endured once its wheels touched the ice was the Sherman tank. It was like landing on a giant washboard, but the airplane held together.

I eased back on the power and gently toed the brakes—a sudden stop would have resulted in a wild sideways slide down the washboard. I came to a stop near a cluster of hangars, shut off the engine, and waited for the arrival of the crash truck, ambulance, and jeep that were racing across the field. The latter undoubtedly contained an administrative type ready to deliver a lecture on disobeying orders.

The jeep stopped and out stepped a surly squadron leader. *To hell with you,* I thought as I climbed out of the cockpit. *I'll tell you what you can do with your "closed" field.*

But there was no run-in. It turned out he had been more concerned with the condition of the aircraft than with orders being violated. While he inspected the landing gear I hopped on the crash truck and asked the driver to drop me at the nearest bar.

Usually a couple of gin and tonics or warm beers or a combination of both could blot out the war for a few hours, but not this night. Either the Martlesham booze was weak, or worse, it wasn't working. I raised my glass in a mock salute to the day's flight—a sea monster, an overheated engine, unfriendly RAF types. The only good thing was that the Spitfire wasn't seriously damaged. An engineer found that a broken shaft had jammed the coolant shutters and prevented air from dissipating heat from the coolant. The airplane would be ready to fly in the morning.

—Jim Griffin

SHAR Center

The Chariot of Indra

Does poverty-stricken India need a space program? The government says yes—and so do the people.

by Sheila Tefft

Photographs by Avinash Pasricha

Sriharikota Island differs little from many sections of coastal India. Stretching across baked mud flats and shallow saltwater channels, a 10-mile causeway reaches from the mainland to the island in the Bay of Bengal. In quiet coastal pools, fishermen ready their nets and skiffs. Loaded bullock carts creak past clusters of mud-and-thatch huts. Farmers cover the road with chaff to be crushed by passing cars. Parched rice paddies await summer rains. But contrary to appearances,

Sriharikota is the hub of India's space program, the most ambitious in the developing world.

The technology developed at Trivandrum's space center has little obvious effect on the town.

Sriharikota is not just another obscure corner of India. The spindle-shaped island is home to India's largest space launch site, the SHAR Center.

For three decades, India has been seeking ways to solve development dilemmas with space science and technology. Although one of the world's poorest countries, India is a full-fledged member of the exclusive club of spacefaring nations, with a space program that is a source of national pride.

Sriharikota, located 60 miles north of the bustling seaport of Madras, was a sleepy backwater when officials scouting for an east coast launch site first arrived in the late 1960s. They were attracted to the spot because it was remote, huge, and sparsely populated. Only a few hundred Yanadi tribal people, believed to be descendants of the subcontinent's first settlers, lived on the tropical island. In the years since then, the area's population has swelled to 50,000, and the SHAR (short for Sriharikota) Center has given the residents plenty to boast about: new jobs, street lights, movie theaters, and prestige. "SHAR has given us a place on the world map," says M.R.S. Kumar, a 28-year-old lawyer who runs his family's soft drink business.

But all has not gone well at SHAR. On March 24, 1987, technicians there were preparing to send a satellite aloft on a new-and-improved Indian rocket called the ASLV (augmented satellite launch vehicle). At the mainland end of the causeway, the Sullurpeta bazaar buzzed with news of the impending launch. In noisy tea stalls and busy liquor shops, there was an air of anticipation. Police reinforcements patrolled the streets. VIPs sped by in cars with darkened windows. A helicopter brought in Prime Minister Rajiv Gandhi, an experienced pilot intent on leading his country into the age of high technology.

Expectations for the launch were running high. Stalled for 15 months by technical problems, it would be the first launch at SHAR in four years and the first ever for the ASLV, a second-generation Indian rocket. The five-stage, 40-ton vehicle featured a sophisticated new guidance system and enough power to boost a 300-pound satellite, more than triple the capacity of the first-generation launch vehicle.

Just after midday, a rumbling spread across marshy plains, and crowds on roads and rooftops for miles around watched the rocket hurtle into the sky. On a terrace five miles from the launch pad, Gandhi, his teenage son Rahul, and 50 other guests observed the rocket's fiery climb.

The excited onlookers didn't know that the flight was already in trouble. Two first-stage strap-on motors burned out and separated from the ASLV right on cue. But a main engine failed to ignite, and the rocket and its payload splashed into the Bay of Bengal.

Rockets take off just down the road, but for Sriharikota's Yanadi natives, life hasn't changed much.

At a press conference held afterward, the prime minister tried to console SHAR's dejected engineers and scientists. "It is only when you stumble that you can get up and walk better," he said, but the words rang hollow to local space enthusiasts. "This program costs us such a fortune," Kumar, the soft drink dealer, says sadly. "We wanted so

much to have a success."

Space has fascinated the people of India for centuries. Hindu mythology offers early images of spaceflight: epic airborne battles between gods and demons, deities flashing across great distances in flying chariots. One favorite story is found in *The Ramayana,* the odyssey of the warrior-king Rama. Sita, his consort, is spirited away to Lanka, the kingdom of the evil Ravana. As Rama battles Ravana's minions for his wife, Ravana flies Sita over the battlefield in his chariot to show her an illusion of Rama dead on the battlefield. In the end, Rama saves Sita and flies her homeward in a chariot sent from heaven by the great god Indra.

Myth was gradually surpassed by reality in the 18th century, when rockets began appearing in India. In 1792 a feisty south Indian ruler, Tippu Sultan, bombarded the British with rockets, forcing his adversaries to add them to their own arsenal.

Even before the launch of Sputnik 1 in 1957, a corps of Indian scientists was deeply involved in space research under the guidance of cosmic ray physicist Vikram Sarabhai at his Physical Research Laboratory in Ahmedabad. Considered the father of the Indian space program, Sarabhai came from a wealthy and philanthropic family of textile manufacturers that has been likened to the Rockefellers.

A man of eclectic interests and boundless energy, Sarabhai wielded considerable clout with Prime Minister Jawaharlal Nehru and shared his vision of a technologically strong India. In the 1960s India was still importing mountains of food, but Nehru and a cadre of influential scientists, including Sarabhai, overrode objections to spending scarce

resources on space. After centuries of foreign dominance, Nehru argued, space exploration could make independent India self-sufficient and strong. In 1962, Nehru created a National Committee for Space Research and made Sarabhai the chairman. One of Sarabhai's first tasks was to establish a United Nations launching range for sounding rockets at Thumba, a tiny fishing hamlet near the southern tip of the country. Because of its location near the geomagnetic equator, rockets launched from Thumba would encounter very low levels of background cosmic radiation, which can interfere with very sensitive measurements.

The first researchers at Thumba worked under rough conditions, commuting every day by bus over miles of unpaved roads, assembling their rockets in a rundown church full of pigeons, and transporting their scientific payloads to the launch pad on bicycles. Today the Vikram Sarabhai Space Center near Thumba is the largest branch of the civilian Indian Space Research Organization (ISRO), created in 1969, and the site for launch technology development.

Sarabhai died in 1971, but his dream of improving the quality of Indian life inspired a generation of young scien-

SHAR Center

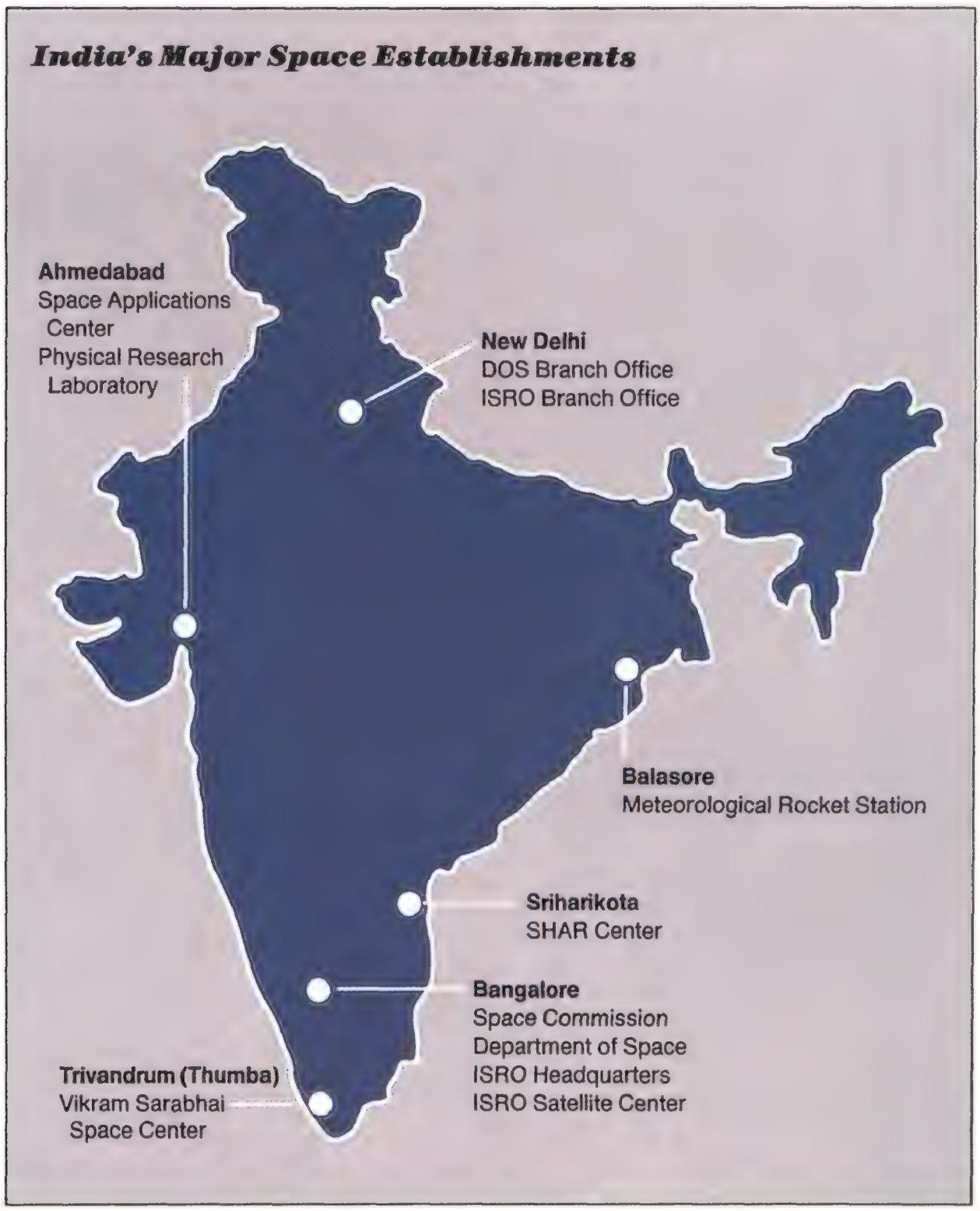
Though dismayed to watch last year's ASLV launch fail, Prime Minister Rajiv Gandhi continued to encourage SHAR engineers. His two predecessors—his mother, Indira Gandhi, and his grandfather, Jawaharlal Nehru—were also supporters of the space program.

SHAR Center

tists. "He said that if a rocket is necessary, then a rocket should be built. And if a satellite is needed, then we should build a satellite," recalls Ekrath Vasanth Chitnis, a long-time associate who served as manager of the Satellite Instruction Television Experiment (SITE) project. "But they must finally deliver the goods: education, development, and alleviation of poverty."

After Sarabhai's death, leadership of the space program passed to Satish Dhawan, at the time head of the prestigious Indian Institute of Science in Bangalore. A dynamic aeronautical engineer, Dhawan had not been part of Sarabhai's coterie. "I was not really involved in the dream of the program," he says. "I didn't get involved until it landed in my lap." In 1972 the Indian government created a new Department of Space to oversee ISRO and other Indian space centers, and Dhawan was named head of both the department and ISRO. The following year the Soviet Union launched India's first satellite, Aryabhata, which was equipped with X-ray astronomy instruments. Since then, India has built and launched seven satellites and five first-generation satellite launchers, while chalking up two launch failures. Dhawan retired in 1984 and U.R. Rao, a student of Sarabhai, has taken his place.

ISRO's U.R. Rao believes his country's space development effort will have many social benefits.



Justifying a $200-million-a-year space program in a country that can't provide safe drinking water and electricity to all its 780 million people hasn't been easy. But after spending more than $1 billion on space research and facilities, India is beginning to collect dividends on its investment. Its biggest success has been the Insat multipurpose satellite system. A project of the Departments of Space and Telecommunications, the Meteorological Department, All India Radio, and the national television network Doordarshan, Insat is revolutionizing communications in India.

Insat grew out of an early experiment in space-based broadcasting. In 1975, though skeptics still insisted that a space program was too newfangled and expensive for a poor country, Dhawan and his colleagues undertook the SITE satellite television project to demonstrate the social benefits of space technology. Via NASA's experimental communications satellite ATS 6, educational TV programs for farmers and students were broadcast to 2,400 villages in six states for a year.

Nowhere is SITE's impact more dramatic than in Pij, a prosperous farming community of 9,000 located about an hour's drive south of Ahmedabad. For the TV experiment, seven stations were built to pick up signals from the ATS satellite and rebroadcast programs to other areas. Pij was singled out to get the first rural station.

For a year, on 600 TV sets, the people in Pij and surrounding villages

After the government built a launch center at Sriharikota, an entire township sprouted around it.

The children of SHAR scientists attend Space Central School, which boasts high scores in nationwide tests.

SHAR employees stage celebrations at the island's open-air recreation center (right).

watched programs in local dialect on animal husbandry, farming, and health. SITE was such a success in Pij that the space program continued to operate the station after the experiment ended. But in 1985 government broadcasting officials dropped a bombshell: the Pij station would be moved to a large city, where it could serve more people. Villagers would not be cut off, they said; Pij would still be able to receive TV signals transmitted from Ahmedabad.

Stunned by the decision, the people of Pij revolted. Insisting that the station belonged to the village, they fasted, marched, and boycotted government offices. When workers arrived to remove the 300-foot-tall tower, women and children sat in the road blocking the trucks. The Pij station was shut down, the tower left sitting idle near the center of town, but the villagers, who have not given up hope, guard it around the clock. Across the street an old man sits under a thatched roof, ready to sound the alarm. "No single knob, nut, or bolt from the transmitter will be allowed to leave our village," says schoolteacher Gopal Khamabholja. "It has become more than the purpose it was put up for. We have been put on the world map by this transmitter."

Today, much of India's telecommunication is handled by Insat satellites, built by Ford Aerospace in the United States to Indian specifications and equipped with remote sensing capabilities. Insat-IB, launched by a U.S. space shuttle in 1983, is currently the only orbiting Insat satellite still functioning, and officials hope it will continue to work until a backup is launched. Insat-IC, originally scheduled for a shuttle launch in September 1986, will be sent aloft by a European Ariane rocket this summer, and Insat-ID will be launched on a U.S. Delta rocket next spring. In the works is a series of five Insat-II satellites; with half again the size and capacity of the Insat-I's, they will be built in India and launched by Indian rockets in the 1990s.

But even the lone Insat-IB has made national TV broadcasting possible: signals relayed by satellite can reach even the most remote villages, and between 60 and 75 percent of the population can now watch TV. Once at least two satellites are in place that figure should rise to 90 percent. Long-distance calling, a frustrating chore on the country's antiquated telephone lines, has been improved by the 4,300 new phone circuits that Insat-IB provides. All India Radio has 93 stations broadcasting via Insat. The Press Trust of India is experimenting with satellite transmission of news: a south Indian newspaper, *The Hindu*, has gone national by relaying facsimile pages from Madras to a New Delhi printing plant via Insat-IB. The satellite also beams back about 5,000 weather pictures a year, supplying vital information about monsoons and violent storms to the rural nation.

Among the changes space exploration and development has brought about, satellite TV is the most significant. Just as television transformed American culture in the 1950s, so it is changing India. Rajiv Gandhi and other politicians use Western-style media campaigns to reach voters. The government accepts program sponsorship from companies touting everything from detergents to low-calorie sweeteners. Educational programs are being edged out by soap operas and situation comedies.

Not all are happy with the new developments. Vikram Sarabhai and his colleagues had considered television an educational tool for a largely illiterate population and a unifier in a country of 14 major languages, and many believe that this vision has become distorted. "What is TV coming to today?" moans Mrinalini Sarabhai, the scientist's widow and a noted Indian classical dancer. "It is becoming third-rate entertainment."

But there is no reversing the TV revolution. Villagers crowd around community sets as avidly as urban families tune in nightly in their apartments.

Although manned spaceflight is not a feature of India's space plans, it captured the country's attention in 1984, when 35-year-old Indian air force officer Rakesh Sharma flew into space with two Soviet cosmonauts for a week aboard the Salyut 7 space station. Via television, millions of Indians watched Sharma eat spicy Indian food from a tube and perform yoga exercises to

NASA

Sovfoto

India is still dependent on the U.S. and Soviet space programs. Launched by space shuttle in 1983, the Insat-IB satellite transmits data to flood-forecasting and cyclone-warning networks and to major telecommunication stations (top). Indian air force officer Rakesh Sharma (bottom, right) spent a week on a Soviet space station in 1984. Last year Soviet leader Mikhail Gorbachev proposed building an international launch center in India, but so far no such project is planned.

Launches from Thumba (right) benefit from the equatorial locale, where background radiation is low.

Most of India's space hardware is built within the country, where over 15,000 people work for the space program.

counter the effects of weightlessness. Because Sharma's flight had been arranged by the military, ISRO was a bit touchy on the subject. "Don't ask me what the benefits were," says Satish Dhawan.

Today Sharma still symbolizes space to many Indians, while practical applications of technology developed in the space program go largely unnoticed. However, regional centers are being created all over India to use the wealth of data that will be beamed back by Indian remote sensing satellites. IRS-1A is scheduled to be launched on a Soviet rocket in the spring. An Indian station now receives remote sensing imagery produced by the U.S. Landsat and the French SPOT satellites, but with data available daily from remote sensing satellites in the 1990s, Indian efforts to boost crop yields, recover wasteland,

SHAR's mission control center will be tense and busy during next spring's ASLV launch.

and locate new water sources will greatly improve.

The next launch of the ASLV is set for this spring, and India plans to start launching two new types of domestically built rockets in the 1990s. The polar- and geosynchronous-satellite launch vehicles will feature liquid-fuel engines to ferry large satellites into space. A new launch site will be needed for the polar-satellite vehicle. Meanwhile, India must

Thousands flock to Thumba's space museum each Wednesday, when it is open to the public.

continue to lean on the United States, the Soviet Union, and Europe to build its space program. When the *Challenger* accident left the launch of Insat-IC in limbo, officials had to scramble for an alternative because no Indian rocket could launch such a big payload. They'd also lost a flight opportunity for the first Indian shuttle crew member—ISRO payload specialists N.C. Bhat and P. Radhakrishnan had been training to fly on the shuttle along with Insat-IC.

India's dependence on other countries for launch service and technical expertise has led to complications. For example, the United States will not permit the export of a U.S.-built satellite to any country if it is to be launched on a Soviet rocket, an arrangement that is common for India because the Soviet Union is a long-standing ally. Furthermore, to forestall a nuclear weapons buildup in developing countries, the United States and six Western allies agreed last year not to export any technology that could be used to make large missiles capable of launching nuclear warheads. India has kept its civilian and military space programs separate, but as is the case in other spacefaring nations, its civilian rocket technology could be readily adapted for military applications. Indian officials admit that the new export control pact will hinder their civilian space program: 50 percent of their satellite parts and 30 percent of their rocket parts must still be imported.

With the non-proliferation agreement in place, India is more determined than ever to be self-reliant in space. "There is no alternative but to develop it entirely on our own," says U.R. Rao, ISRO's chief. "We are confident that we can do it." With almost evangelical zeal, more than 15,000 scientists, engineers, and technicians work toward that goal at more than a dozen space centers throughout the country. The ISRO Satellite Center in Bangalore is already bursting at the seams as workers standing shoulder to shoulder assemble satellites, while at the Vikram Sarabhai Space Center engineers iron out kinks in rocket designs.

The people of India are proud of their country's space achievements. The loud criticisms of space spending in the '60s and '70s have given way to acceptance and even enthusiastic support. To many Indians, a full-fledged space program befits a regional power on the brink of becoming a world force, and few question the government's contentions that India can save money and gain stature by building and lofting its own satellites instead of relying on the technology of other countries. But officials know they can't afford to explore space just for prestige. The country's rockets and satellites will ultimately have to deliver what Vikram Sarabhai wanted: greater literacy, better living conditions, less poverty. "How has the poor man in India benefited?" asks Satish Dhawan. "We must answer, 'Not a lot yet.' But he has hope."

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Resist the Pull of Mars

A few small steps can go farther than a giant leap.

John Logsdon,
Director, Space
Policy Institute at
George Washington
University

A moon base is an essential stage of expansion beyond Earth.

Mars is beckoning. With all the mystery and promise of prestige that lured Americans to the moon, the Red Planet has captured a powerful and vocal cadre in the aerospace community. But these planners of the next U.S. space voyages are considering destination when they should be contemplating destiny. However bold a mission to Mars may seem now, history will show it to be merely an expensive detour unless it is carried out as a step in the systematic progression toward the settlement of space. Other space programs—most notably the Soviet Union's but also those of Europe and Japan—are already making a commitment to humanity's expansion beyond its home planet. Recently the White House proposed that extending human activity beyond Earth orbit should be a major goal of U.S. space policy. This goal, uncluttered by demands for social benefit or political gain, should become the guiding vision that U.S. space efforts have lacked.

If the United States is to help advance the evolution of humankind from an Earth-dwelling species to a multiplanet one, NASA must develop a long-term strategy for space exploration that includes both a permanent return to the moon and subsequent missions to explore and eventually inhabit Mars. Adopting this strategy does not mean imposing a schedule of expenditures or accomplishments. It does mean investing now in the technologies that will make space settlement possible.

A NASA advisory panel concluded in March 1987 that "the planet Mars, for centuries an object of intrigue, stands out as the one entity most likely to capture widespread enthusiasm and support, while pulling considerable scientific and technical capability in its wake .... We should make exploring and prospecting Mars our primary goal, and should so state publicly." This reasoning is the legacy of Project Apollo, which accelerated the U.S. space program in the 1960s by committing the country to the most dramatic undertaking then feasible—a manned mission to the moon. But once Armstrong and Aldrin and their successors had been to the moon and back, there was no compelling reason to keep returning. Without a scheme for future exploration, there was no need for the hardware used to launch Apollo, so in 1970 President Nixon and the Congress also ended the Saturn V program, thereby stopping production of the heavy-lift launcher we now badly need.

But Mars calls with more than the assurance of Apollo-like glamour and public applause. Some support a Mars mission for its global political payoff. Carl Sagan advocates U.S.-Soviet cooperation in a program of intense Martian exploration. He envisions a culminating mission with a crew of Americans, Soviets, and probably representatives of several other nations. While Sagan offers a variety of cogent reasons for concentrating unmanned exploratory activities on Mars, he admits that the primary reason for including a human journey in the plan is political. He believes that the cooperation of the United States and the Soviet Union in a long-term, challenging, peaceful, and widely admired enterprise would reduce the likelihood of nuclear conflict.

It is difficult to argue against any activity that would prevent nuclear war, but it is

reasonable to ask whether a 21st century collaboration will have the political impact now projected and whether the development of the U.S. space program ought to be linked to the constantly changing character of the U.S.-Soviet relationship. Even if the response to both questions is yes, why limit U.S.-Soviet cooperation to exploration of Mars? Why not include the moon as well? Certainly the technologies being developed by the Soviet Union, particularly the heavy-lift launcher Energiya, are well suited to sending human beings to the moon.

Establishing a permanent base on the moon is an essential stage of expansion beyond Earth. Human beings should go to Mars, but it does not make sense to bypass the moon, a celestial island just offshore that offers significant knowledge for colonizing space. Getting to the moon is a three-day hop, compared with a months- or years-long journey to and from the Red Planet, which is approximately 200 times farther away. There is no question that human beings could make a lunar journey: it has been done nine times. Transportation systems already planned for moving payloads from low Earth orbit to other locations in space can be adapted for early lunar trips.

The experience gained in establishing an outpost on the moon would be unarguably beneficial to a Mars trip, particularly if the eventual intent is to establish a permanent settlement on the Martian surface. Our current level of knowledge will support only limited human operations on Mars. Experiments on the moon with the techniques and processes required to sustain humans in a lunar outpost—in civil and chemical engineering, in physiology and medicine, in agriculture—can only aid the development of effective systems for Martian bases. The moon's proximity makes it a wiser choice for such experiments because a mistake made there would be easier to correct than one on Mars. Crews could come home at any time; there would be no weeks- or months-long wait for the next launch window.

The moon is itself scientifically interesting and can support various experiments that are difficult or impossible to conduct on Earth. The scientific returns from Apollo have proved that the moon is a keystone for understanding the origins of the solar system. Additional lunar studies would enhance that knowledge. The dark far side of the moon may be uniquely suited for an astronomical facility modeled on the set of observatories atop Mauna Kea in Hawaii. It may soon be the only place in the solar system where sensitive radio astronomy can be carried out without interference from terrestrial signals. Other types of interference present on Earth, such as light pollution, would also be absent. A lunar observatory would be much more likely to detect planets around other stars and thus focus the search for extraterrestrial life.

No settlement of the moon or Mars is possible if settlers must import everything from Earth. If the vision of permanent human expansion into space is ever to be realized, the ability to use the resources of other planets must be developed. The use of lunar resources such as oxygen, silicon, and aluminum, all present in significant concentrations, to support the moon base is a logical first step in this development. Some believe that lunar oxygen will also find use as a fuel for space transportation systems operating between low Earth orbit and other points in space.

For all of these reasons the moon, not Mars, is the next logical locale for developing U.S. space capabilities. This was the conclusion reached last year by former astronaut Sally K. Ride and her associates in an assessment of NASA's future options. Their report, *Leadership and America's Future in Space,* says that "Mars should be our eventual goal, but it should not be our next goal . . . . We should adopt a strategy of natural progression which leads, step by step, in an orderly, unhurried way, inexorably toward Mars."

This is wise counsel, and accords with the classic strategy for space development that has been espoused for more than a half-century by such pioneers as Hermann Oberth, Wernher von Braun, and Thomas Paine. Pursuit of this progression of goals requires that we develop reliable and affordable space transportation systems, establish orbital outposts for use as both research facilities and essential waystations on the way to Mars, and build bases on the lunar surface. Underlying this strategy is the human imperative to explore and ultimately inhabit celestial bodies other than Earth. This is the objective that should guide space development—not just political payoff, economic benefits, or military advantage.

Not all will agree that it is time to begin moving some human activities off this planet. However, given humankind's ambitions and technical capabilities, it is hard to believe that such movement will never happen. So the question is really when, not if, and what role the United States will play.

Our current knowledge will support only limited operations on Mars.

The Deregulation Diet

At 95 cents a meal, you just can't please everyone.

by Elaine de Man

Chef Joseph W. Lhotka sat at a table for eight in the Grand Ballroom of San Diego's Hotel Inter-Continental waiting for his dinner. He was growing impatient. The service lacked style and efficiency, he thought, and his roll was stale. "Like the kind you get on an airline," he grumbled.

A lukewarm lobster bisque was followed by champagne sorbet. Assorted spring greens with marinated goat cheese and walnut vinaigrette accompanied the main course: broiled veal chop with wild mushroom sauce. Ray Anthony fired up his orchestra and couples in tuxedos and sequined gowns took to the dance floor. But Lhotka sat waiting for dessert. At last he was served orange parfait with cognac—"rather bland," he complained.

Criticism from Chef Lhotka is not to be taken lightly. He trained at the Garten School in Munich and has worked in some of Europe's finest hotels: the Kronenhoh near St. Moritz, the Kronehalle in Zurich, the Hilton in Cairo. He has fed heads of state from all over the world: in 1958 he was one of three palace chefs for Iraq's King Faisal. Twenty years ago he chose to forsake the glamour of the royal kitchens to become the executive chef at Mack Brothers, a Chicago meat house that catered mainly to restaurants. In 1984 Mack Brothers became Jet Chef, a leading supplier of in-flight food that prepares some 18 million meals a year, and today Lhotka is the president of Jet Chef.

Though airline food and beverage sales are approaching $3 billion a year, the industry still counts its pennies.

The black-tie banquet was the culmination of the Inflight Food Service Association (IFSA) Annual Conference held last April. Nearly 800 airline caterers, suppliers, and representatives enjoyed a weekend of lectures, workshops, exhibits, tennis, golf, and parties. No expense was spared. This is big business: despite deregulation and the dramatically low fares it created, airline food and beverage sales are approaching $3 billion a year.

Still, it is an industry that counts its pennies. As the first decade of deregulation caused the airlines to tighten their belts, all those providing essential supplies and services, including food, had to follow suit. "In the last four years, the cost is going one way: down," says Lhotka, with a trace of his native Austrian accent. "Meals we made three or four years ago for $1.15 or $1.20 we now make for 95 cents." The difference seems miniscule until you consider that a savings of a penny a meal can equal $350,000 a year for a major airline like United.

Fred Martin, president of the major in-flight caterer Dobbs International, noted at the IFSA conference that 88 percent of the airlines use price, not quality, as the major criterion when selecting a caterer. According to a Department of Transportation survey, Pan Am, the high roller of U.S. carriers, spends an average of $6.20 per passenger on meals and beverages. Aloha, which services the Hawaiian islands, spends 10 cents. The average among U.S. carriers is $3.60.

Several years ago an airline director

Jordan Coonrad

Ray Anthony's orchestra catered to guests' musical tastes at the Inflight Food Service Association banquet.

Jordan Coonrad

Tulkoff's Tiger Sauce was a hot item at the tradeshow, where customers grazed on in-flight food samples.

asked Lhotka to duplicate a fillet-of-sole dinner served at the Four Seasons in New York City. The restaurant charged $26, but Lhotka was able to whittle the cost to the airline down to $3.60. When he made his presentation, however, he says the response was " 'Are you crazy? Three dollars and sixty cents? No way. No *way*.' That's just one of the inadequacies you have to deal with."

Attempts to go beyond the norm can create other problems as well. When Delta inaugurated service to London it planned to serve beef Wellington to first-class passengers. But two days before the first flight the chefs still didn't have an acceptable recipe. "I don't know how many times we fixed that beef Wellington," recalls Jan Rake, a staff manager for Delta's dining service planning, "but every time we put it into the airplane oven, it burned." About that time a supplier dropped off a sample of English muffins. After she had exhausted all possibilities, Rake put the muffins in the bottom of the Wellington pan to absorb the grease that was making the entree burn. *Voilà.* "It was perfect," she says. "And to this day when we cook beef Wellington, we do it with English muffins."

During the convention, a bevy of executive chefs and culinary experts presented IFSA with solutions to the problem of better meals for less money. Their recommendations were nearly unanimous: more sandwiches, grilled chicken breasts, ethnic food, lighter and healthier meals, and packaged snacks. Lhotka, for one, was not impressed. "Nothing is better than a good sandwich," he says, "but nothing is worse than a bad one." Experience has shown that sandwiches end up either dry or soggy, depending on what's between the bread. And a grilled chicken breast may look attractive on the plate, but by the time the passenger attempts to take a bite it can be tough as shoe leather.

Pan Am spends $6.20 per passenger on meals; Aloha, only 10 cents.

The recommendation that appeared to be the most practical was the already well-established "picnic basket" filled

Jordan Coonrad

with brand-name snacks, such as Quaker Chewy Granola Bars, Nabisco crackers, Nestle's chocolate bars, and Sun-Maid raisins. This, the consultants reasoned, would be perceived as quality food and satisfy the current trend of "grazing." This, countered Lhotka, is junk food.

Trying to get a group of chefs to agree on a meal is bad enough, but that quandary pales in the face of trying to do the same with millions of passengers. Food service people have found that what passengers say they want and what they actually eat are often quite different. "We allowed ourselves to fall

It may look good on the plate, but by the time a passenger gets a grilled chicken breast it may be tough as shoe leather.

into a trap," says Rake. "We were told time and time again that people want lighter meals. So we replaced the ice cream sundae with a sorbet. But the hue and cry from the passengers was unbelievable. 'I'm on a diet five days a week,' they said. 'When I get on an airplane I want the ice cream sundae.' " So while surveys show that Americans are concerned with nutrition, onboard experience shows they're not concerned with it when flying.

After the scheduled meetings and parties, the darkened hallways of the Inter-Continental resembled a rabbit warren full of conventioneers hopping from one hospitality suite to another. Dobbs International, which had the two-story Presidential Suite on the 25th floor, drew crowds with a live band and a bathtub brimming with bubbles. "No one does any business here," said one guest, licking his ice cream cone. "It's just a chance to meet the people you deal with all year. I played golf all day."

On the floor below, Marriott Corporation, the big cheese of airline caterers, held court in a more subdued fashion. A tuxedoed pianist provided background

Marriott Corporation

Artful meals designed to please both eye and palate are losing out to snacks packed in cardboard boxes.

music while guests nibbled mussels, oysters, and sushi. An adjoining suite was converted into an A & W Root Beer stand, similar to the one "Mr. Marriott," as he was referred to by employees, opened in Washington, D.C., in 1927 when root beer was a nickel a mug. Ten years later J. Willard Marriott observed passengers buying sandwiches and coffee to take out to Washington Hoover Airport. He immediately contracted with Eastern Airlines to provide meal service on airplanes departing from Washington. Then he sold American Airlines on the idea. Today Marriott In-Flite Services operates 96 kitchens worldwide, serves 150 airlines, and packages more than 150 million meals a year.

Over the years the in-flight food industry has evolved a peculiar division of responsibilities. The suppliers and caterers each negotiate directly with the airlines, which set prices that dictate what is going to be served where. Each

"Nothing is better than a good sandwich," one caterer says, "but nothing is worse than a bad one."

airline has its own guidelines for meals and snacks based on departure time and length of the flight. Every supplier is commissioned by the airlines to deliver its product—frozen entrees, soda, cheese balls, plastic dinnerware—directly to the catering service, which then assembles the meals and delivers them to the airplane, where flight attendants serve them to the passengers.

Orchestrating the timely delivery of the correct numbers of meals in the proper galley carts for each aircraft configuration is as complex a chore as air traffic control. One IFSA speaker noted that U.S. airlines spend nearly $25 million a year on meals that end up in the garbage because passengers book flights they don't take or miss a connecting flight. (But if there's a shortage of meals on board, the crew must give up theirs: flight attendants first, cockpit crew last.) And when a big airline swallows a little one, it acquires a fleet of airplanes with different galleys, which multiplies the caterers' woes.

Airline food has become a legend in its own time. Passengers call it "a contradiction in terms." Flight attendants have facetiously recommended using the omelets as flotation devices in case of a water landing. Some airline officials have suggested that a certain "mystery meat" could be used to patch holes in luggage. Even George Lang, a restaurant owner and consultant who spoke at the convention, referred to airline food as "brown meat with gray sauce or brown sauce with gray meat, whatever it is."

It isn't just low budgets that have fueled this perception. The unique serving conditions aboard an airliner also contribute. The Food and Drug Administration requires that the meal be delivered to the airplane at 45 degrees Fahrenheit or cooler. Then it must be rapidly reheated to serving temperature and, if the flight is delayed, held there. The gray, brown, or white sauce that has become synonymous with in-flight food protects the meals during such extreme handling.

In defense of the airlines' efforts, Robert Marshall, a student at the School of Hotel Administration at Cornell University, presented IFSA members with the results of a survey he conducted. Out of 610 passengers polled at various airports, 77 percent felt that airline meals have gotten better or stayed the same, and 70 percent were indifferent to airline food service when choosing an airline—scheduling and price came first. And in a D.A.L. Aviation survey of *Fortune* 1,000 company executives who made frequent business flights, only five percent named the food as their major air travel complaint.

Has the food gotten worse since deregulation? "The passengers got to fly coast to coast for a hundred bucks—that's what they got out of deregulation," says Bill Stephens, managing partner of Royal In-Flight Catering in San Antonio, Texas. "It might be unrealistic to think that at $99 the meal is going to be the same as when they were

Less Filling, Tastes Great?

Several years ago a newspaper article announced that kosher meals were the most expensive served by the airlines. The flying public, figuring that if it cost more it must be better, proceeded to inundate the airlines with requests for kosher meals.

"They didn't realize," says Delta's Jan Rake, "that kosher meals have to be made at an outside plant, shipped to our kitchen, and then the caterer charges us to handle it." Kosher meals, prepared under the supervision of a rabbi, aren't any better than non-kosher; they just pass through more hands.

Most airlines offer meals to accommodate social, religious, and medical requirements. When reserving a seat, passengers can order a special meal from a list that varies slightly from carrier to carrier. Delta, for example, has 15 meals to meet the specific needs of everyone from babies to vegetarians. The majority consist of "low" this or that: calories, cholesterol, fat, or salt. There are also dual-purpose meals—low-cholesterol doubles as low-fat. Those who request the Moslem meal will get either the kosher or the vegetarian, which may be the same as another airline's Hindu meal.

At Delta, which boards 90,000 special meals a month (less than three percent of the total boarded), the most frequently requested is the vegetarian, followed by fruit, kosher, and seafood. Meals ordered for "health and fitness" are further down. At the end of the list is bland, which on some airlines doubles as soft.

Some airlines use special meals as a marketing gimmick to reward frequent fliers. Members of TWA's Frequent Flyer program can order a Kansas City barbecue platter or sole Napa Valley when they book a flight. Actually, any TWA passenger can request one of these meals; frequent fliers are simply better informed.

But whether they're offered for religious, health, or prestige purposes, special meals cause special problems for just about everyone involved. There is no industry standardization. The specifications for a Hindu meal are unique to every airline that offers one. Some caterers specialize in kosher meals, but beyond that the airlines are on their own. As a result some have pared down the variety of special meals. "We can't accommodate all types of diabetics, for example," says one caterer, "because we haven't talked to all their doctors." Industry executives are concerned over the lack of standardization, particularly in meals requested for medical reasons. They fear someone will get the wrong meal someday and sue. "I think we've been lucky up to now," says a Marriott In-Flite vice president.

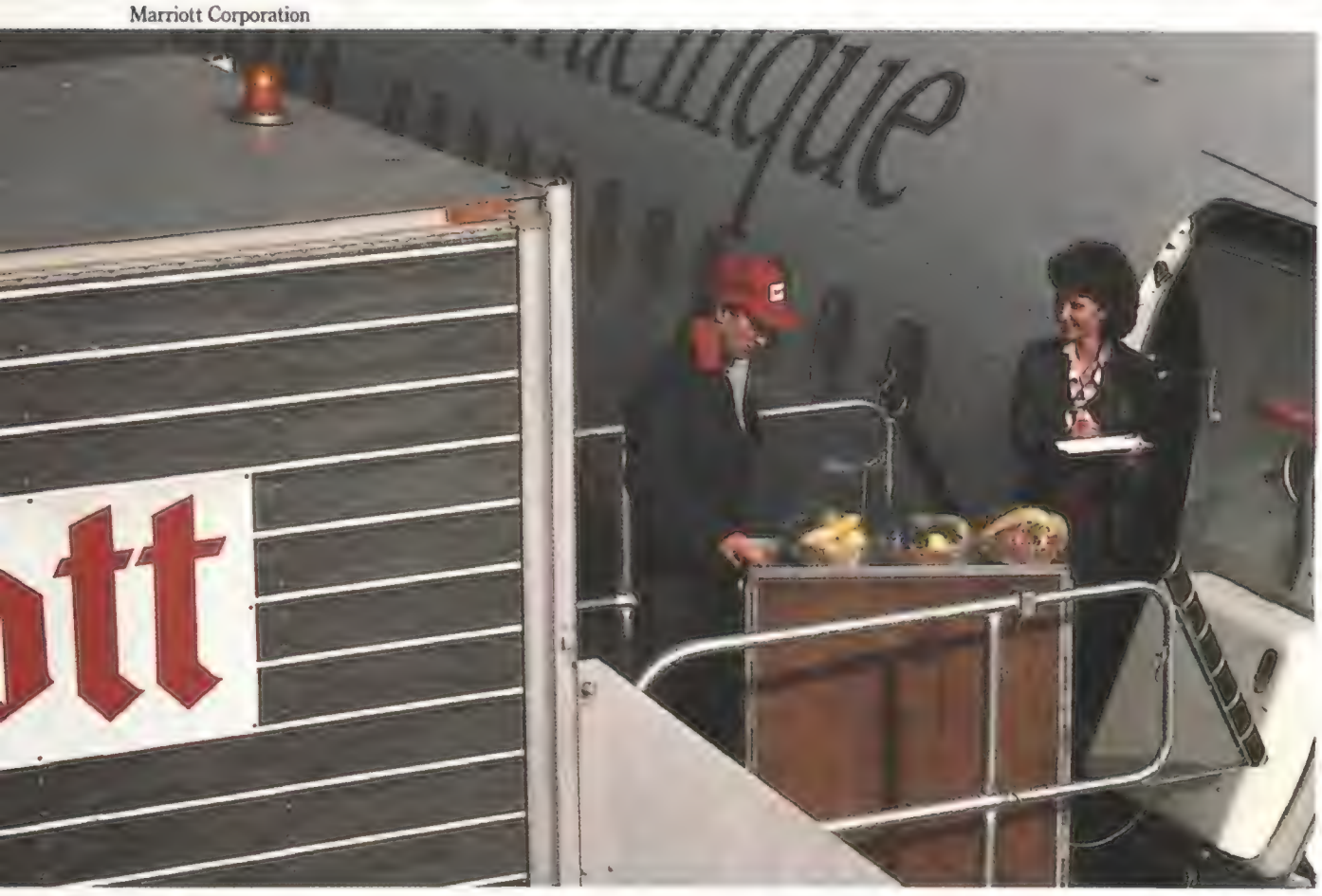
Given the chain of command, it's sheer luck that special meals get served at all. Four out of five are requested through a travel agency, which passes the request to the airline, which gives instructions to the caterer, who must remember to tell the flight attendants where the special meal is. If the passenger who ordered it doesn't show up for the flight, the airline is stuck with it. But because most passengers are still convinced the special meals are superior, getting rid of it isn't much of a problem.

—Elaine de Man

paying $600. But if the quality of the meal has gone down, and I don't think it has, it hasn't gone down anywhere near the proportion of the ticket price."

When deregulation set off a search for cheaper meals, it also opened the doors for small independent caterers like Royal In-Flight. Airlines scheduled flights to towns that were too small or too out of the way for catering giants, so new caterers formed to service them.

Marriott Corporation



Deregulation's cheap fares mean cheap food, but most passengers choose cost over cuisine when booking a flight.

"Deregulation allowed me to go into business," says Stephens, who had been in the restaurant business for six years before joining Royal In-Flight. "TWA came to San Antonio, and they went with us."

"It's very difficult to break into the airline industry," says Susan Axelrod, president of Love and Quiches, a baked-goods supplier. "The airlines are creatures of habit. It's a small industry and they take care of each other. But when you make a sale, it's a decent volume, and that's what we're looking for. If you sell them only one item, you're talking about thousands of portions a month." Suppliers scramble to get on board. "Here's a cheese spread you can freeze and refreeze," a vendor calls to a passing flight attendant at the IFSA tradeshow.

Occasionally the suppliers are more responsible than the airlines for what appears on your tray table. Every year, from the moment they fasten their seat belts to the time they deplane, a captive audience of 414 million U.S. passengers serves as a revealing cross-section of the population. "It's not just the upper crust that flies anymore," says Andy Woods, a spokesman for Eagle Snacks. "Everyone flies." And even though the airlines might represent only 10 to 20 percent of their total market, manufacturers are hungry for that airborne test market.

What passengers say they want and what they actually eat are quite different.

When Anheuser-Busch entered the snack market, they used the airlines to help launch Eagle Honey Roast Peanuts. In 1982 they started selling the nuts to the airlines at a bargain price, and when Eagle snacks finally appeared on grocery shelves in 1985 the public gobbled them up. Today the airlines represent only 15 percent of Eagle's "nut dollars"—groceries, convenience stores, and bars account for the rest.

"It's a tremendous advertising gimmick," says David Becker, a representative for Jim Beam distilleries. "Most airlines board only one or two bourbons, one or two gins, or whatever. But if you're one of those products, you pretty much have a locked audience." Traditional methods of sampling—giveaways, discount coupons—cost the manufacturer money. But by selling to the airlines they make money and expose the product simultaneously. At least one airline representative at the IFSA conference remarked that perhaps it was time the airlines start charging the manufacturers.

Money figures in every aspect of food service, down to the weight of the plastic glasses. Juice, for example, will be appearing more often in small paper cartons. According to Tetra Pak, manufacturer of the aseptic paper packaging, stocking juice in its cartons instead of the traditional six-ounce can could cut an airline fleet's weight by nearly five million pounds a year. The reduction of just one pound, says the company, means an annual savings of up to $40.

Regardless of the penny pinching, the industry consensus is that in-flight food is going to improve. "I think we've bottomed out," says Lhotka. "In the last 20 years I've seen the quality of the food go up and down but never as low as it is now. Either we've got to take food off completely or only serve cheese and crackers. But I don't think that's going to happen, because there's too much competition." Nevertheless, last November Eastern announced it would switch from hot meals to cold sandwiches on flights of two to three hours, and remove food service entirely from some of its shorter flights.

In-flight food may never regain the status it held in the halcyon days before deregulation. Lhotka remembers when airlines were serving filet mignon, and if TWA served a four-ounce steak United would up theirs by half an ounce and American would top it with five. Right now about the most you can hope for is a second bag of peanuts.

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Artful Fliers

Lively, romantic—if somewhat innocent—early aviation posters recall an era when flight was sport.

by Henry S. Villard

It promised to reveal "how the world looks from above," but the dirigible was far less enticing to poster artists than the airplane.

Swiss Transport Museum, Lucerne (1912)

An ebullient era's fascination with flight lives on in this classic poster from a French air meet (opposite). Luckily, the few fliers who fell into the sea proved as buoyant as their spirits.

When powered human flight became a reality in the early years of the 20th century, aviators became the era's most glamorized heroes. Flying emerged as a full-fledged sport, and the flying exhibition, or air meet, became its arena. There, like knights of the Middle Ages, daring pilots in helmet, scarf, and goggles jousted for prizes and the plaudits of the multitude.

Colorful posters accompanied the meets, publicizing the events to draw crowds. Individually, the posters celebrated the passion of an innocent age for its new winged marvels. As a group, they helped chart early flight's rapid evolution and its pilots' accumulating skills. What they occasionally lacked in technical detail they made up for in emotional eloquence: they reflected the excitement of witnessing human flight.

Posters announcing aeronautical events were nothing new: they had long publicized balloon ascensions at fairs and carnivals, calling attention to the occasional spine-tingling parachute drop or attempt to break a record, as well as the cash prizes offered. A *Fêtes Aérostatiques* organized in 1906 by the city of Pau, a fashionable winter resort in the south of France, offered 5,000 francs to the first balloonist daring enough to cross the Pyrenees. On the delightful poster designed for the occasion, a rapidly rising balloon and fanciful flight of birds vie for attention with a ravishing, auburn-haired woman in décolletage, whose bare arms are raised, evidently in anticipation of the aeronautical thrills in store.

The rigid dirigible made an airborne passenger service feasible in the early 1900s. Count von Zeppelin's airship transport company, the Deutsche Luftschiffahrts Aktien Gesellschaft, issued a 1912 poster with the eye-catching title "How the World Looks From Above" to attract paying passengers for the excursions it offered over the German countryside. A poster printed by France's Compagnie Générale Transaérienne in 1909 warmly romanticized the state of the art, depicting a dirigible poised in the splendor of the setting sun over a mountain-rimmed lake. For the most part, though, the dirigible's rotund shape, unwieldy size, and slow speed inspired few poster artists.

The flying machine held promise of powers that had long been restricted to the province of myth and of gods. Yet public enthusiasm wasn't awakened until the summer of 1908, four and a half years after the Wright brothers' first powered flight, when Wilbur Wright demonstrated to enthralled crowds in France that the airplane was a fact of contemporary life. European excitement increased a year later when Louis Blériot flew his frail 25-horsepower monoplane across the English Channel—an exploit that sent patriotic Frenchmen into a frenzy and caused the startled British to exclaim, "There are no islands anymore!" The stage was set for the first great gathering of airmen.

In the wake of Wright's demonstrations, leading French experimenters eagerly signed up for what was to have been the world's first aviation competition. It never took place. Under the auspices of the International Sporting Club of Monaco, the meet was scheduled to open on January 24, 1909. The exhibition's poster later made vague promises for February and March. The meet was then delayed until April, and finally abandoned altogether.

The meet's poster, perhaps the first to pair

Science Museum, London (1910)

Science Museum, London (1909)

A stylish couple cavorting high above the Mediterranean epitomized the new-found joys of flight. But the advertised meet at Monte Carlo never took place.

Science Museum, London (1909)

Asked to attend the world's first aviation meet in Reims, France, Wilbur Wright scoffed, "Let others amuse themselves with races if they want to." They did, and the meet was wildly successful.

Swiss Transport Museum, Lucerne (1909)

Popular French aviator Hubert Latham could fly like an eagle; on an imaginative German poster, he also looked like one.

the airplane with the suggestion that flying lifted one high above mundane affairs, remains an irresistible attraction. Precariously seated at the controls of what might pass for a primitive Wright biplane, a fastidiously dressed gentleman in aviator's cap, ascot, yellow gloves, and boutonniere guides his craft high above Monte Carlo. Beside him, a beguiling companion of *la belle époque* clings delicately with one hand to a strut, a scarf flying loosely round her head. With such an exuberance of color and so superb a view of Monte Carlo, it hardly seems to matter that the woman's skirt is unruffled by the wind or that a pointed cylinder—evidently the fuel tank—is the only sign of a motor.

The first true aviation meet took place one month after Blériot's flight. From August 22 to 29, 1909, 28 intrepid pioneers assembled on the plain of Bétheny near Reims in northern France for a *Grande Semaine d'Aviation de la Champagne,* an aviation week sponsored by the local champagne industry. With 200,000 francs in prize money, the meet was an immense success and attracted hundreds of thousands of spectators—150,000 on the last day alone.

The softly tinted sky in Parisian artist Edouard Montaut's fetching poster for the event indicates that sunset is near, a time of day when the wind was apt to drop and flying was considered safer. A svelte female spectator, back to the viewer, lifts her arm in salute to an armada of aircraft rising like a swarm of bees from the distant outlines of Reims' celebrated cathedral. Four balloons and a dirigible hover far in the background. From the undulating zebra stripes of the woman's costume to the determined expression on the face of the nearest pilot, images of motion and speed fill the scene.

The idea of noted fliers pitting their skills and machines against one another spread contagiously from country to country following the Reims meet. One of the most unusual of early aviation posters announced the first of the week-long meetings that would lend distinction to Johannisthal, a suburb of Berlin. Celebrating the inaugural *Flug Woche* in September 1909, it shows a soaring eagle with the aristocratic features of French aviator Hubert Latham.

Debonair, cool, and proficient, Latham had become the *liebling* of the young women during exhibitions at the nearby Tempelhof parade grounds; engaged to fly at Johannisthal, he piloted his beautiful Antoinette monoplane between the two towns on the first cross-country flight in Germany, a distance of about

NASM (1910)

Aviators at the Belmont Park competition delighted crowds with a race to the Statue of Liberty and back.

Science Museum, London (1909)

First by a slim margin, the Doncaster, England meet unfortunately overlapped with another held the same week.

Science Museum, London (1910)

six and a half miles. Popular enthusiasm for the handsome flier and his feat spilled over into meets at Spa, Cologne, and Frankfurt, fueling an interest in aviation that would take Germany to record-breaking heights before the outbreak of the first world war.

The growing popularity of the meets fostered some ill-timed competition. A poster promoting "England's First Aviation Races" at Doncaster in the midlands was printed in the fall of 1909 by the Great Northern Railway to publicize its special train service and excursion rates to the seven-day event. Extended by two days because of the weather, the gathering ended up coinciding with a meet at the western seaside town of Blackpool, under the endorsement of the recently formed Aero Club of Great Britain. The poor timing, bad weather, and local rivalries detracted from both and did little to enhance public interest in flying. The Doncaster meet did produce one good thing: with its head-on view of a white-winged Blériot pursued by a biplane in a sky of limitless blue, its poster is a model of simplicity, power, and purity of line.

The United States' first meet opened in January 1910 at Dominguez Field near Los Angeles. A gaily extravagant program cover takes a bird's-eye view of the city, showing it flanked by luxuriant waving palms and clumps of winter roses. The sky above is populated indiscriminately with biplanes, monoplanes, balloons, and dirigibles but dominated by the prevailing U.S. favorite, the Wright. The promoters outdid themselves in hyperbole: "Under blue skies, the atmosphere laden with the perfume of flowers and the scent of orange blossoms, Los Angeles has added the most lustrous jewel to her diadem of world fame . . . the only place . . . where in the month of January the atmosphere is balmy, light and warm enough for . . . a successful meet."

In February, European fliers found suitable weather in Egypt for a week-long meet at Heliopolis, outside Cairo. An evocative poster poignantly contrasts old with new: a Bedouin astride a camel shades his eyes and gazes across the pyramid-studded landscape at the latest in transportation—half a dozen fabulous flying machines maneuvering above.

During the months that followed, meets were held in places as diverse as Vienna, Budapest, St. Petersburg (now Leningrad), Bournemouth, Boston, Lanark, and New York. But France was the scene of the most activity. The poster for an aviation week at Lyon contrasts a mellow, old-world setting with a demonstration of new-age aircraft in action. From a flower-decked balustrade overlooking

Swiss Transport Museum, Lucerne (1912)

The development of the hydroplane, night flying, and aerial acrobatics in 1912 and 1913 widened pilots' horizons and brought new dimensions to poster art.

RAF Museum, London (1912)

To promote a meet in his hometown, Milanese artist Aldo Mazza used the graceful form of the French Antoinette in his poster (opposite).

Swiss Transport Museum, Lucerne (1913)

Myth and reality merged in the form of a Fokker F.II portrayed in an early airline poster.

Royal Dutch Airlines (KLM) (1923)

the town's river, a modish lady in a gargantuan hat flutters her handkerchief at a passing Blériot—an image that appears repeatedly in the posters and programs of the day. Not to be outdone by the example set in Reims in 1909, Lyon also posted prizes totaling 200,000 francs in an attempt to lure the top talent in aviation.

In August, a second meeting at Reims raised the ante to 250,000 francs: the poster for that gathering presents a lordly eagle leading a flock of man-made birds as symbol of man's new-found supremacy in the skies. At Bordeaux in September, capping prizes of 200,000 francs, President Armand Fallières offered a magnificent silver and bronze trophy as an incentive to French airplane builders. Titled "*l'Essor,*" or "Flight," it, too, took the eagle as a model. For overall excellence in various events it was awarded to Léon Morane for the house of Blériot; the engagingly naive monoplane that spreads its snowy wings across the Bordeaux poster, however, looks less like a Blériot than an Antoinette.

One of the most stunning early aviation posters was created by local artist Aldo Mazza for Milan's first international air meet, held in the fall of 1910. There is no doubt about the identity of the monoplane that soars past the fretted pinnacles of the great Gothic cathedral: its clean-cut lines, long slender fuselage, skid-equipped undercarriage, and fancy sweeping tail stamp it unmistakably as an Antoinette. The aviator is crouched realistically over the control wheels as glowing, pastel shades of sunset suffuse the entire scene. The poster, of almost photographic clarity, captures the poesy of flight while adding an authenticity of detail that had never before been seen in aviation posters.

Because horse-race courses made natural aerodromes, New York's 1910 international tournament was held at the well-known track at Belmont Park in Long Island. An eye-catching poster featuring a radiant sun behind a flying machine lured spectators by the trainload to watch U.S., French, and British fliers test their wings during the last 10 days of October. Society was represented in force as the hero of the moment, the dashing Claude Grahame-White, claimed the coveted Gordon Bennett Cup for England by speeding around the course at over 60 mph.

By 1911, man had clearly mastered his wings. That was the year of the great races: Paris-Madrid, Paris-Rome, the Circuit of Britain, the Circuit of Europe. Instead of keeping close to the confines of an aerodrome, contestants now flew long distances in all kinds

of weather. The Circuit of Europe race covered a distance of nearly 1,000 miles and offered a staggering total of 450,000 francs in prizes. A huge poster for the event catches a courageous and resolute aviator as he sets out on the most challenging competition yet—the inevitable scarf streaming behind him, the blurred disk of his whirring propeller, a panorama of the English Channel below.

Air meets, and their posters, were naturally eclipsed by the Great War of 1914 to 1918. Once the war ended, flying itself began to follow a new course as entrepreneurs explored the development of commercial air transport. A richly colored 1921 poster publicized Latécoère airline's service to France, Spain, and Morocco, with Africa's ready welcome symbolized by a robed figure on barren soil opening his arms to an approaching airliner. Two years later, the Royal Dutch Air Service issued an imaginative poster in which the captain of the *Flying Dutchman,* sailing upon a storm-tossed sea, is called upon to witness that, thanks to the airplane, "Fiction Becomes Fact" and the legendary ghost ship's name has taken on a literal meaning. Of the increasing number of air transport posters, a 1926 product of Farman Air Lines is more typical. It shows a sleek new monoplane, its comfortable cabin filled with passengers, ascending steeply toward fluffy clouds.

Charles Lindbergh's solo flight from New York to Paris in 1927 gave an incalculable boost to air travel. It seemed made to order for a patriotic organization called the Comité Francais de Propagande Aéronautique, which aimed to quiet any lingering skeptics and foster the spirit of aviation in France.

In 1928 the committee distributed a poster commemorating Henri Farman's 1908 circuit of one kilometer and Dieudonné Costes and Joseph Le Brix's trip around the world 20 years later, which included the first nonstop crossing of the south Atlantic. The poster shows the ghost of Joseph Prudhomme, caricaturist Henri Monnier's narrow-minded, solemn, self-satisfied *petit bourgeois,* watching his frazzled son hurry to catch a modern airliner.

This poster stood at the crossroads of two eras. Aviation poster art was becoming more practical-minded. Instead of promoting the drama and daredevilry of air meets, it began devoting itself largely to extolling the speed, comfort, and elegance of air travel. Of the many accomplishments of those remarkable two decades that intervened, the parting slogan of the Comité's poster neatly summed up one: "No More Skeptics." ✈

Musée de l'Air, Paris (1928)

In commemoration of aviation milestones separated by 20 years, a French poster gently satirized flight's newest generation.

by Stephan Wilkinson

Painting by Barron Storey

X-29

The combination of technologies in the newest research airplane enables it to outfly anybody—including the researchers.

Whoever says the Grumman X-29 looks as though it's flying in reverse has never seen it aloft. Like Greg Louganis on the high board, the X-29's thin wings thrust inevitably, naturally forward in an endless swan dive that reaffirms the old adage "If it looks good, it'll fly good."

Lookin' good, the X-29 cavorts through the California sky above Edwards Air Force Base. The airplane is at

20,000 feet and 20 miles from Edwards, but it is being closely tracked back on the ground by a camera with a howitzer-sized lens. Inside a NASA control room, the country's first true high-performance research jet since the X-15 dances across a three- by five-foot TV projection screen linked to the big camera. A second screen displays a moving map across which the X-29's snail trail creeps—here the knot of a windup turn, there the squiggle of a couple of rolls. Yet another monitor offers a cartoony but vivid computer-generated image of the view from the airplane's cockpit. Blue sky, gray runways, and ancient yellow lakebeds rotate soundlessly.

Alien in appearance, the X-29 is a hybrid of the familiar: part F-5, part F-16, part computer.

Well, not exactly soundlessly. The air conditioning is humming, computer fans are whirring, and an engineer is drumming his fingers on a console in nervous boredom. Mission controller Donna Knighton's occasional muttered commands punctuate the regular rasp of the pilot's oxygen flow, picked up by his mike and amplified over the control room loudspeakers.

"Stand by, we're ready to reverse to

Grumman Corp.

the left," Knighton murmurs. "That's good . . . go to card 21." The numbered cards list maneuvers. "Full left rudder . . . stand by for release . . . release . . . full right rudder . . . release . . . stand by for rolls, and the flight control people want to remind you not to feed in aft stick."

"Yes ma'am."

Picture Chuck Yeager being worked by Knighton and you realize test flying isn't what it used to be. On to card 22. Up on a big screen a T-38 Talon flashes past in the distance like a faked-out cornerback. The X-29 may not be breathing hard, but the older trainer trying to fly chase can't stay with it.

The principal benefit of the X-29's unusual forward-swept wing is reduced drag, but improved agility could turn out to be one of its biggest payoffs. "Agility is the rate of change of the aircraft state with precision and control," says Major Harry Walker, the Air Force test pilot assigned to the X-29. "If I can maneuver my airplane in a way that makes my intent and action ambiguous to an opponent, I can beat up on him . . . and kill 'im." He smiles thinly.

There is some argument about the relevance of that agility, though. "Turning to engage"—the fighter pilot's pri-

James Sugar/Black Star

mary maneuver—may not be useful in future combat. Over-the-horizon identification, fire-and-forget smart missiles, and stealthy characteristics could well become more important than duking it out with iron guns at 9 Gs. But even if they don't use the word anymore, some pilots are not quite ready to kiss off the dogfight.

Robert Shaw, for one. A former Navy F-4 and F-14 pilot and author of the textbook *Fighter Combat: Tactics and Maneuvering,* he insists, "You don't ever want to give away maneuverability in a fighter. In Vietnam, much to our chagrin, we found out that [long-range] missiles were only about 10 percent reliable. We also shot down a couple of our own planes early in the war." Losses from their own missiles led the brass to order visual identification of targets, Shaw recalls. "And if you have to visually ID the other guy, you're almost already in the maneuvering environment"—in other words, a dogfight.

Mission controller Donna Knighton is wired to research aircraft by video, voice, and data links.

The X-29 is not an especially agile airplane—not right now, anyway. Its roll rate is only two-thirds of the 200 degrees per second considered the norm for modern fighters, and its controls are not particularly well-harmonized. Some have even compared its handling—begging the X-29's pardon—to a transport's.

"But the shortcomings are almost by intention," explains NASA Dryden chief pilot William Dana, who had flown the airplane on this day for the first time. "The aircraft is obviously airworthy, and Grumman didn't want to waste time changing the control laws [software that rules the airplane's flight control computer] to make it handle perfectly. It's intended to be a technology demonstrator, not a handling paragon."

Even if the airplane is not pushed to the limit, it has the potential for extreme agility. In terms of accepted airplane behavior, the X-29 is a very naughty bird—it's unstable.

A stable airplane—Piper Cub, DC-10, any traditional airplane—wants to fly straight and level all by itself. Even if the pilot takes his hands off the controls and a gust of wind disturbs it, the stable airplane tends to return to level flight. Unstable airplanes want to diverge from level flight. Disturb them and they go into alternating climbs and dives that increase in severity. The X-29 will double its divergence every 150 milliseconds. Unaided, the airplane would go out of control literally instantly. You wouldn't have time to *think* "whoa, Nellie," much less say it.

NASA

Wing and canard are coupled aerodynamically: each has an effect on the other's airflow.

Not to worry, though: the X-29 isn't flown by a whoa-Nellying human but by three primary digital flight control computers, with three analog computer backups that could get the airplane home if they had to. As fast as 40 times a second, the primary computers assess the airplane's position and attitude, analyze the requests transmitted by the pilot's control movements, decide what needs to be done to keep the airplane flying nose-first while satisfying the pilot's inputs, and send signals to hydraulic actuators that readjust the control surfaces the imperceptible amounts necessary to retain the happy state called stability.

Instability can come in awfully handy, though, if rapid changes in course, direction, angle, rate, or position—"aircraft state," in Harry Walker's words—are needed. In a dogfight, the stable airplane is like a nose-heavy car with skinny, slippery tires: turn the steering wheel and it wants to keep going straight ahead.

Rogers Smith is one of NASA's X-29 project pilots, Walker's civilian equivalent and partner in the test program. Smith's hair has receded from a scholarly forehead, and he looks like a professor. Or an engineer, which he is. "Instability is only half the equation," Smith explains. "If you get a maneuver started, you have to stop it, too."

"I can tumble the X-29 in half a second, it's so unstable," says Walker. "But then I can't stop it. The best I can hope in combat is that the bad guy watches and says, 'What is he *doing?*' and gets out of way before he gets hurt. But it really does me no good to be able to turn


NO SMOKING

my nose toward someone at a hundred degrees a second if I then overshoot by thirty."

Sometime this fall, the second X-29 (Grumman has built only two) will begin probing extremely high angles of attack—"high alpha" in engineerspeak. At times the X-29 will stand on its tail, 70 and perhaps even 90 degrees to its direction of flight, moving forward—or simply falling straight down—while still under some measure of control.

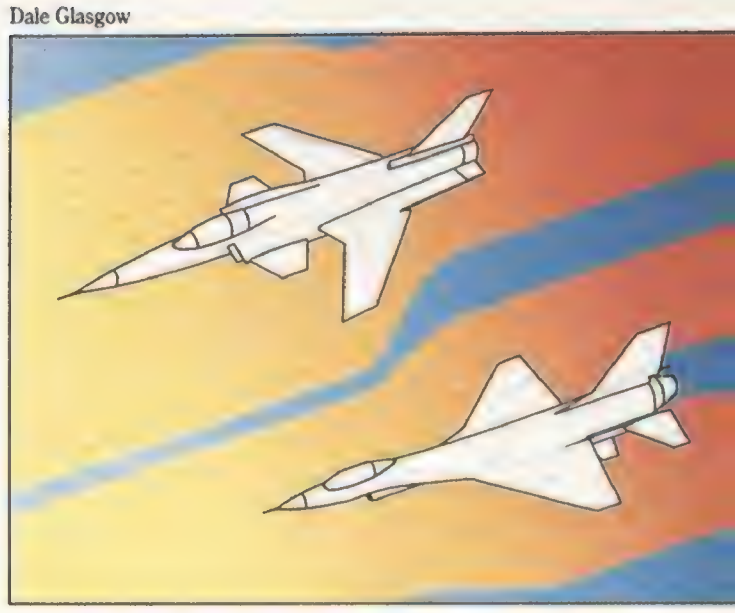
Such radical behavior opens up the possibility of entirely new and deceptive maneuvers—virtually stopping in flight, say, while a pursuer flies past you and becomes the pursued. High-alpha capability could become the modern equivalent of the impossibly tight maneuvers of World War I pilots who exploited the torque of their rotary engines, which created gyroscopic forces that could accelerate turns until the airplane seemed to pivot in midair.

"It all boils down to pitch-pointing," Walker explains. "The current generation of fighters can turn at 350 knots [more than 400 mph] at 7 to 9 Gs. You talk to the guy who gets beat in a circling dogfight and he invariably says, 'I ran out of aft stick.' I want more pitch-pointing capability all the way down to my minimum airspeed . . . . And by the way, don't think the pilot's G-loading capability is the limiting factor ("High Gs, High Risk," October/November 1987). We've got some interesting developments coming up that will take care of that."

Another reason the airplane is potentially agile is that it "tends to levitate," as X-29 design team chief Glenn Spacht puts it. When a pilot gives the "nose up" command in a conventional airplane by pulling the stick back, the airplane's elevator deflects upward, pushing the tail down. The airplane rotates around its center of gravity, which increases the wings' angle of attack and creates additional lift. Give it throttle and the airplane climbs. In the X-29, pulling back on the stick commands the canards to increase their angle of attack and the variable-camber trailing edge flaps to deploy slightly. The result: instant lift, hold the pitch.

Grumman built the X-29 not for fun or out of intellectual curiosity but to play catch-up. "In 1978, when we got serious about the project, the last new design we'd undertaken was the F-14," Spacht says. (Aerospace industry people never use a military aircraft's given name; it's considered irredeemably dorky to call an airplane a "Fighting Falcon" or a "Hornet.") "Other people had experience with relaxed static stability and we didn't. So in order to position ourselves for the next generation of tactical aircraft . . . the company needed a focal point."

Dale Glasgow



Aft-swept wings lose controllability when air flows toward the tips; forward sweep solves the problem.

The X-29 is in considerable part cobbled together from the remains of other airplanes. "That's my cockpit," laughs Grumman's Thomas Garner, a former F-4 pilot whose last Air Force job was to pick out an F-5 nose section from the scrap heap to use on the X-29. "I didn't have that much choice, though. There were only two old A-models parked in the boneyard, and one had been in an accident."

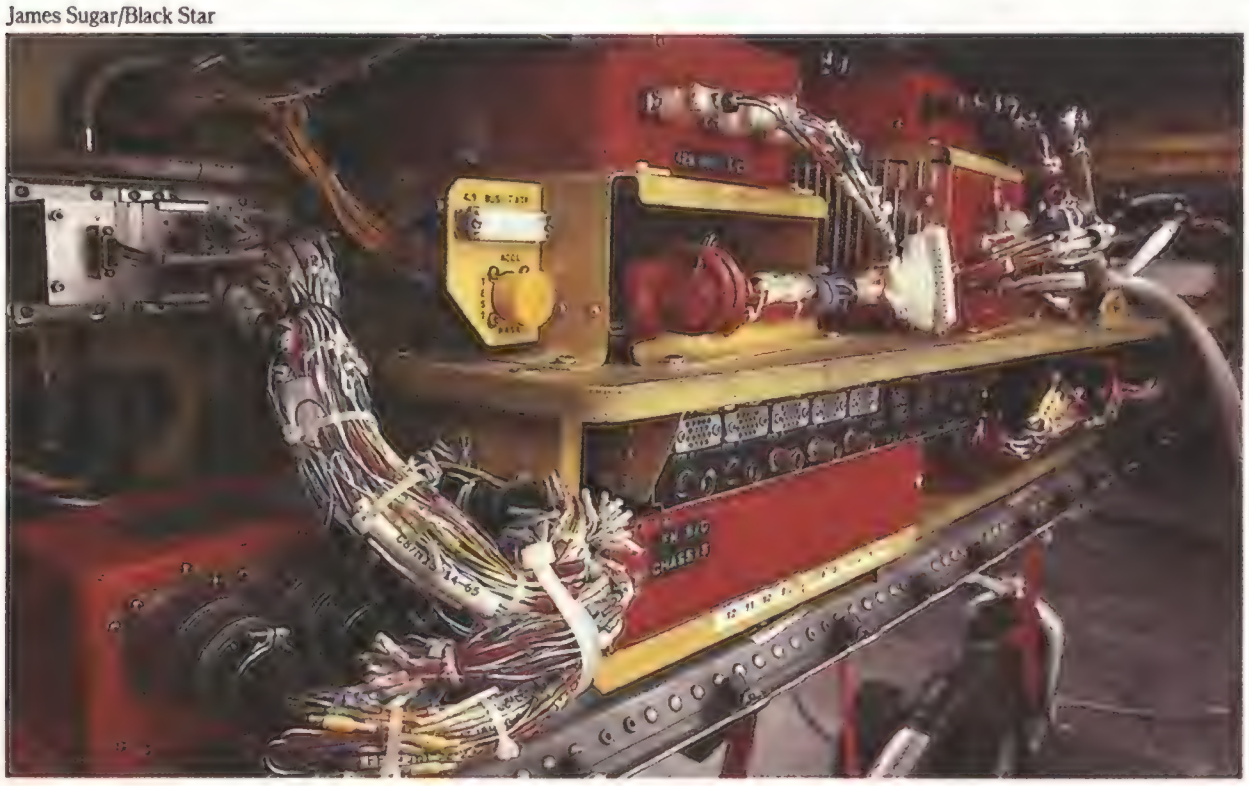
Garner's chunk was lopped off and sent to the Grumman works in Bethpage, New York, as was a main landing gear set from an F-16 Falcon. The hydraulic motors that move the X-29's control surfaces are also F-16 parts, and the flight control computers are autopilot controllers for the Lockheed SR-71 Blackbird. "Yeah, they're old-fashioned," agrees NASA X-29 deputy program manager David Lux, "but these were what was available in the mid-'70s, remember." Not just available but, more important, flight-qualified. By employing used bits, engineers cut down on the time needed to prove the key parts were flyable.

"The cockpit's the place you can see it's kind of a junkyard dog," Spacht says, though it is clear he prefers a faithful mongrel to an overwrought poodle. "It's got an F-5 stick and rudder pedals, and there's an engine instrument that's got one side taped over because it's a gauge out of an F-18, which has two engines. In fact, we had a gauge failure

Composites—darker portions of the wings—prevent adverse twists that once defeated forward sweep (left).

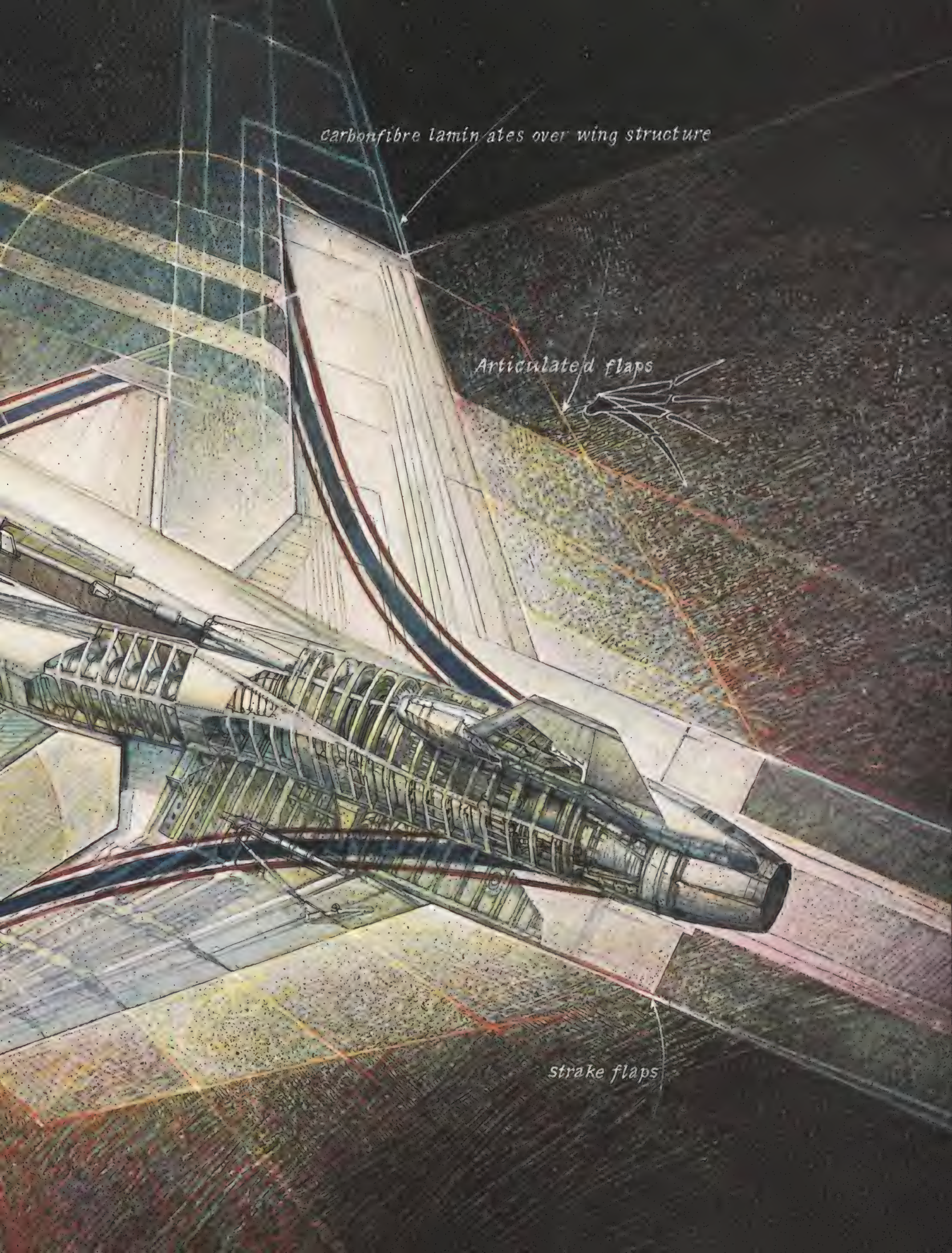
Without the help of its computer reflexes, the X-29 would be a handful no human could manage.

James Sugar/Black Star



Grumman Corp.


THE GRUMMAN X-29
X-29
Airflow over forward swept wing
Canard movement - 30° up, 60° down


carbonfibre lamin ates over wing structure
Articulated flaps
strake flaps

awhile ago, and we fixed it by switching the plug on the back and moving the masking tape from one side to the other."

Beyond the largely hidden complexity of its technologies, the X-29 is a surprisingly limited airplane—so limited, in fact, that test flights are suspended in the event of the lightest rain, the thinnest overcast. Weather that wouldn't deter a private pilot grounds the X-29: it doesn't have a heated pitot tube, for example, and ice could clog it at high altitudes. The 150-odd pressure-sensing static ports sprinkled over the wing also make rainy weather anathema to the ground crew, which would need days to drain the system.

If there's anything "wrong" with the X-29, it's that it violates a fundamental rule of experimentation: the more variables in an experiment, the less clear its

James Sugar/Black Star

Grumman Corp.

Germany's Junkers Ju 287 revealed the problem with forward sweep: structural failure at high speed.

NASA Dryden's chief pilot William Dana found the X-29 "nimble" despite mild control responses.

results. In the old days, experimental airplanes usually tested a single design feature—the swept wing or a tail-less configuration—and proved or disproved its efficacy. The X-29, however, flies with the help of several major mysteries, and separating the boons of one from the benefits of another is proving nearly impossible.

It's confusing enough that its wings defy convention; they also use the first extremely thin supercritical airfoil on a manned aircraft, roughly five percent as thick as it is long (from leading to trailing edge).

For roll control, the wings have neither ailerons nor spoilers but an adjustable trailing edge that varies the wing's camber—the amount of curvature in the shape of its cross-section.

As if that weren't enough, the wing is powerfully affected by a close-coupled co-planar canard—the big flippers just ahead of the wings. Co-planar because they're directly in line with the wings, coupled because in combination both the canard and the wing work together. Airflow over each surface influences the way the other surface reacts.

And the water is further muddied by the fact that this is a "three-surface airplane," the third surface being a unique one called a strake flap on both sides of the tail. All three surfaces influence the airplane in pitch.

"We've been asked by a lot of good people, How do you separate and quantify the technologies?" Rogers Smith ac-

knowledges. "But it's a fully integrated design . . . . We're trying to separate them now, and freeze as many parameters as we can."

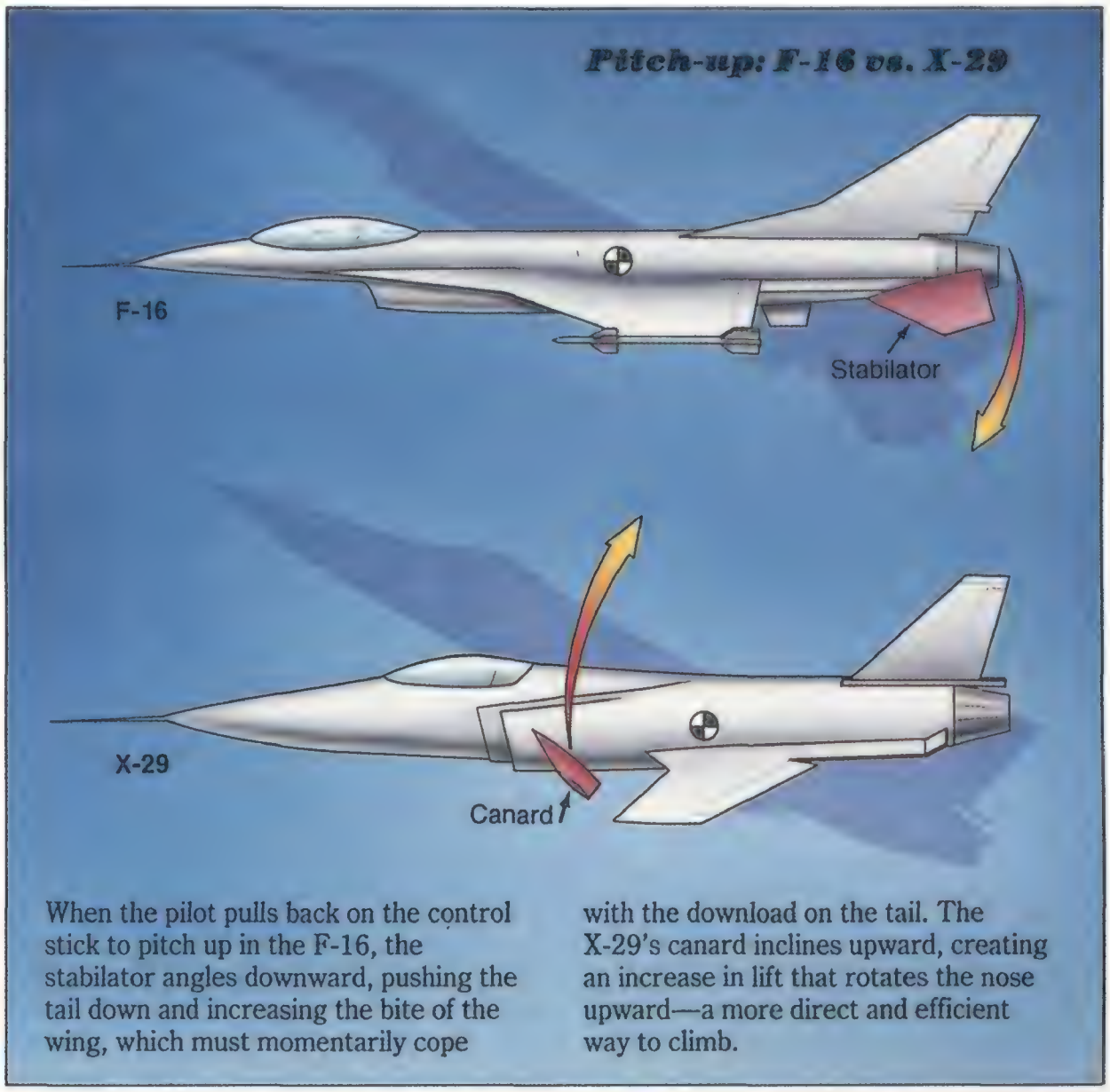
One technique being used to keep the engineers sane is called RAV—"remotely augmented vehicle." A flight control computer on the ground sends signals to the airplane in flight, remote-controlling a piece of it at a time. "You need to find out how effective the various surfaces are," Lux explains. "What amount of pitch is created by the strake flaps, the canard, the camber flaps? With RAV, we can input a pulse to the canard alone, say, and from the response of the aircraft quantify its effectiveness."

Say it ain't so! Does that mean someday soon test pilots will be replaced by computers? Lux smiles. "Don't say that around here." At NASA's Dryden Flight Center—the formal name for some ramp space and hangars rented from the Air Force at Edwards—the test pilots' offices are among the nicer accommodations. The engineers and project managers work in harsh, windowless cubicles, with perhaps a Gary Larson cartoon for decoration. The pilots get carpeting, an expansive wall of windows giving onto the sunny ramp, and handsome color blowups of their favorite airplanes on the walls. The X-29's ground crew sees to it that the pilots lighten up occasionally. On the skirt of the bubble canopy is stenciled the legend "TODAY'S DRIVER," followed by whatever pilot's name the ground crew has grease-penciled on.

The engineers refer to test pilots as "the guy in the hole," as in "Okay, let's throw the guy in the hole and get this show on the road." Still, says Lux, "the best computer we have in the aircraft is the 10 pounds that sits on the pilot's shoulders. Precisely repeated maneuvers the computers do better. But to assess handling qualities, it's necessary to have a pilot. Our engineers can look at the data and say, 'There's buffeting.' But only a pilot can tell you how much and whether it matters."

Before the X-29's first flight, made by Grumman chief pilot Chuck Sewell on December 14, 1984, people had genuine concerns about whether so unstable an airplane could work. Most of the questions centered not on whether computers could fly an airplane—the F-16 proved that ("The Electric Jet," December 1986/January 1987)—but on complex interactions between the wing and canard surfaces and on "aeroservoelastic instability"—a potential interaction that would involve not only the control surfaces themselves but the sensors and actuators that control them. Would the system be able to keep up with changes in airflow as a variety of control surfaces moved in partnership, or would it instantly magnify airflow forces, perhaps to the point of destruction?

Dale Glasgow



When the pilot pulls back on the control stick to pitch up in the F-16, the stabilator angles downward, pushing the tail down and increasing the bite of the wing, which must momentarily cope with the download on the tail. The X-29's canard inclines upward, creating an increase in lift that rotates the nose upward—a more direct and efficient way to climb.

The X-29 leaves little margin for mechanical or electronic unreliability. Though its flight control computers have backups, the only connections between the pilot's controls and the flight control surfaces are small electrical wires carrying commands to the actuators—no cables, no pulleys, no hydraulic lines.

"I can fly an unstable aircraft," says Harry Walker. "The Wright Brothers did. But it depends what speed you're at. At Mach 1.4, you don't have as much time to worry about a pitch excursion as you did at 40 knots." The Wright *Flyer* was demandingly unstable by modern standards—but obviously flyable. The General Dynamics F-16 is most definitely unstable—so much so that several early examples of the fighter were lost due to electrical failures. But the X-29 . . . well, the F-16 is five percent unstable, in aerodynamic terms; the X-29 is around 35 percent unstable. Says Grumman engineer Robert August, "For the first time in an aircraft of this class, the flight control system is as integral a part of the design as is the wing."

Since a total electrical failure would leave the airplane uncontrollable, the X-29 has an emergency generator powered by a small bomb of hydrazine—fiercely unstable rocket fuel—but the generator is good only for a little over five minutes. Lose all electrical power and there's just one emergency

procedure: you get out.

In the event of lesser failures, though, a computer-run flight control system could actually be a boon. "You could include some decision-making ability—make it almost a smart system," explains James Pruner, the Air Force's acting X-29 program manager. Says Lux, "There's going to be an intelligence built right into the aircraft, a certain amount of logic built right into the computer. Say you're flying low, in an attack, and you get hit, lose an aileron. The system reconfigures itself automatically and gets the pilot home."

There's a good reason for building an airplane with a forward-swept wing, and there's an equally good reason why it has never been done successfully before: "structural divergence," a polite way of saying "the tendency to bend and break off." When a wing lifts, it inevitably bends upward a bit. But when metal wings are swept forward, a force bending the wing upward tends to twist the leading edge upward, which increases the wing's lift, bending it farther upward—and so on, to destruction.

The only way to prevent that from happening is to build a forward-swept wing so stiff that it doesn't bend at all. It can be done with metal, and has, but the resulting wing is so heavy that all the advantages of sweeping the wing forward in the first place are lost. Grumman did it with composites—high-tech blends of plastics and tiny carbon strands, a kind of ultimate fiberglass. Some feel that the weight-reducing benefits, strength, and "aeroelastic tailoring"—artful layering according to the warp and woof of the stiffening filaments—of the hardened plastic fabric represent the most potentially important technology aboard the X-29. Forget computers and variable camber, forward-swept wings and agility—the ability to build enormously strong yet light fighters out of plastic could mean more to the Air Force than all the rest of the X-29 put together.

"If you reduce weight, you increase every other performance area," air combat expert Robert Shaw says. "If you could make a fighter completely out of composites and reduce the overall weight by 50 percent, say, a lot of these other factors, like enhanced agility, would seem far less important."

But how composites behave under pressure and over time is still a bit of a mystery. Aluminum absorbs stresses: it bends, groans, cracks, and finally fails if pushed too far. Composite structures are imperturbable until their ultimate limit is reached—then they fail totally. "Composites don't have the ability to absorb energy, take load gradually and gracefully the way sheet metal does," says David Thurston, a consulting aeronautical engineer who has worked with composites as well as aluminum.

"We had a tiny delamination inside a wheel well," Rogers Smith recalls. "You could hardly see it—just a thin

Grumman Corp.

Would a future fighter look like this? Experts say the X-29 lacks the required stealth technology.

line. Grumman said, 'Aw, we'll just shoot some glue in there,' but some university expert looked at it and said, 'This could be disastrous.' I wondered, was I suddenly going to be flying around in a cloud of filaments? We were down for a month deciding how to fix it, because this is unfamiliar technology."

Is the X-29 tomorrow's fighter today? No way. "The window for the next fighter has come and gone, and the X-29 missed it," says Lux. "You won't see the ATF [the planned Advanced Tactical Fighter] with a forward-swept wing." Says Glenn Spacht, "Along the way, ATF became influenced as much by stealth as by traditional fighter values, in my opinion."

So what's the point of it all? Smith says, "You look at an X airplane and say, 'Why are we doing this?' And a lot of times, you have to answer, 'I'm not sure.' Perhaps someone, somewhere, will learn something. Can you operate with reduced control margins? What type of computer do you need to handle strange situations? Can we get by without one of these control surfaces? If we were all-wise, we might know what the applications of these technologies might be. But we're not. We're in the business of filling the data bank."

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THE HUNDRED-MILE

by J.E. Ferrell

Rusty Schweickart has ridden a fiery rocket into orbit at five miles a second. He has lived for 10 days with only the thin shell of an Apollo spacecraft separating him from the cold vacuum of outer space. But when he stood before a group of 24 fellow space travelers one morning in 1985 and tapped his glass for quiet, he was so nervous he could hear his heart beating.

After four years of sending out feelers, holding meetings, and battling politics, Schweickart was presiding over the first official gathering of the Association of Space Explorers, one of the most exclusive organizations in the world. Spaceflight experience is the sole criterion for membership, limiting the potential roster to the 200 or so men and women around the world who have flown on U.S. and Soviet missions.

Of those space explorers, the ASE has drawn 52 members from 16 countries, including the United States, the Soviet Union, Bulgaria, Cuba, Czechoslovakia, East and West Germany, France, Hungary, Mexico, Mongolia, the Netherlands, Poland, Romania, Saudi Arabia, and Vietnam. Their stated purpose is to encourage the exploration and development of space for the benefit of all humankind. Despite their different national backgrounds, the members do their best to avoid political issues that might divide the group.

Schweickart, who co-founded the group with cosmonaut Alexei Leonov, joined NASA in 1963, one of the first astronauts who had not been a test pilot. In his 1974 book *Carrying the Fire,* Apollo astronaut Michael Collins described his colleague as "a blithe spirit, eager, inquisitive mind, quick with a cutting retort, not appreciated by the 'old heads.' Mildly non-conformist, with a wide range of interests, contrasting sharply with the blinders-on preoccupation shown by many astronauts." All that still applies, with some allowance for the mellowing of age.

When Schweickart flew on his first and last space mission, Apollo 9, in March 1969, a jammed camera led to an epiphany: the glitch gave him five minutes with nothing to do but look at the glowing blue and white Earth, a lone harbor of life in the vastness of space. "The input occurred during the flight," he says. "The output I've been working with and thinking about ever since."

The idea for the association grew out of a meeting with Jim Hickman of California's Esalen Institute, an organization that helped start the human potential movement. At a 1981 reception honoring visiting Soviet diplomats, Hickman, who ran an Esalen-sponsored Soviet-U.S. exchange program, asked Schweickart if he was interested in parapsychology, as was cosmonaut Georgi Grechko.

Schweickart answered no. But, he added, he *was* interested in something else: getting together with cosmonauts to share experiences of flying in space, of seeing "the home planet as a whole," as he puts it.

Hickman discussed the idea with officials in the Soviet Union in the spring of 1982. Schweickart, who had left NASA in 1979 to become California governor Jerry Brown's science and technology advisor and subsequently took over as chairman of the California Energy Commission, made his first trip to Moscow in July 1982 to lecture on energy policy at the Soviet Academy of Sciences. Hickman accompanied him, and they met with cosmonauts Leonov, Grechko, and Vitaly Sevastianov. The five spacefarers agreed to hold an association planning meeting in April 1983 in the Soviet Union.

Before that meeting was held,

Caroline Sheen

-HIGH CLUB

There's only one requirement to join the Association of Space Explorers. But it's a doozy.

Schweickart discussed the idea of an association with U.S. astronauts. "Much concern was expressed about the difficulty of staying out of international politics," he recalls. "Many feared that the Soviets would attempt and succeed in simply using such an event for narrow political goals, and that we would be too naive to avoid this. I shared this concern."

Those issues were addressed and settled at the April meeting, says Schweickart: "We decided at the beginning that we would not be political." In attendance were U.S. astronauts Michael Collins, Edgar Mitchell—a strong supporter of the association—and Schweickart; cosmonauts Alexei Yeliseyev, Leonov, Sevastianov, and Valery Kubasov; three interpreters; Jim Hickman; and an assortment of U.S. and Soviet support staff. Discussions among the space travelers revealed "an intense common concern for the environmental quality of the planet," according to Schweickart.

Yeliseyev had orbited Earth for the first time in 1969 and was affected by what he saw. "You can see human damage," the tall, square-jawed cosmonaut says. "You can see contamination of the atmosphere, of the rivers, large oil spots on the ocean, big forest fires. We could see how dangerous that was for the rest of the Earth."

Those at the April meeting agreed that the theme of the first official gathering of the ASE would be "The Home Planet." They also decided to have one more planning meeting in 1983 in the United States. But the meeting was

ASE members (left to right) Ivanov, Schweickart, Makarov, Leonov, and Wang met at the National Air and Space Museum last winter.

Caroline Sheen

Three-time shuttle flier Charlie Walker wants to spread the word about the opportunities in space.

postponed twice, first by the shooting down of Korean Airlines flight 007, then by the Soviet withdrawal from the 1984 summer Olympics.

In spite of political troubles, the ASE's first congress was finally scheduled for October 1985 at a ninth century abbey in Cernay, France, a site found by astronaut Edgar Mitchell. To coordinate preparations, Schweickart, Mitchell, and Hickman set up a computerized communication system to link the members across continents and time zones. The computer linkup is still in use and provides vital communications among ASE members, who see one another only once or twice a year.

During the first congress, the 25 space explorers in attendance shared their thoughts on how spaceflight had changed their perception of Earth. Sultan bin Salman Al-Saud of Saudi Arabia, who flew on the space shuttle *Discovery* in 1985, set the tone of the meeting at the opening session: "The first day or so in orbit, we all pointed to our countries. The third or fourth day we were pointing to continents. By the fifth day, we were aware only of one Earth."

At the first congress the members drafted a charter and planned their next meeting, which was held in Budapest, Hungary, in October 1986. The theme was "Toward Space Civilization," and 32 members attended, among them Hungary's Bertalan Farkas, who flew on a Soviet space mission in 1980. Last October, 31 members—including Mexico's Rodolfo Neri Vela, who flew on a space shuttle mission in 1985—gathered in Mexico City for the third ASE congress, "The Next Generation in Space." The members present approved a list of goals: to encourage joint U.S.-Soviet manned spaceflights, promote international cooperative space experimentation, stir up interest in the development of an international space rescue capability, and stimulate the study of manned missions to Mars. During a two-hour session at the Museum of Technology, broadcast around Mexico live via satellite, ASE members took questions from the press and the public.

The association's growing membership does not include any active NASA astronauts, even though most of the cosmonauts who belong are still active in the Soviet space program. "NASA headquarters made it clear that it would support us so long as what we did wouldn't conflict with U.S. policies—which it does not, because the state department has determined that it does not," says Schweickart, who cleared the group's activities with the department and the White House before the first congress. "It was John Young"—then the head of NASA's astronaut office at Johnson Space Center in Houston—"and his boss, George Abbey, who denied permission of their people to attend our meetings." And in the past, NASA's office of international affairs has been less than helpful to the ASE, he notes, even though current NASA administrator James Fletcher has said he supports the association.

According to former shuttle pilot Robert Overmyer, who joined the ASE after quitting the astronaut corps in 1986 to work for the aerospace industry, Young's concern was that by meeting with foreign space travelers, NASA astronauts might be perceived as negotiating with them as government representatives. Young and Abbey transferred out of the astronaut office last year, and Schweickart intends to keep talking with NASA about the difference between official and unofficial policy.

Some astronauts, current and former, disapprove of their fellow explorers' involvement in a group that includes Soviet citizens. "I've had criticism from other astronauts," says Alan Bean, who walked on the moon in 1969 and lived in Skylab for nearly two months in 1973. "I ask them, 'What have you done this week to improve relations between the United States and the Soviet Union? What did you do last month?' Well, they say they haven't done anything, yet they criticize this avenue. I feel that doing this is better than doing nothing."

Schweickart bristles at any suggestion that he or the members of the ASE have some hidden political agenda. "We don't address Star Wars," he says. "We are not a peace group." However, politics can't be avoided entirely. "The world is still unfortunately broken up by national boundaries," he observes, "and the organization reflects that external reality." In other words, its members still struggle with differences.

Some are minor: the Soviet members, whose participation in the ASE is funded by their government, don't understand why the U.S. government doesn't offer similar support to American members. Because U.S. spacefarers participate as individuals rather than employees of the government, they have formed a separate arm of the ASE to raise money. The president of the ASE-USA is Taylor Wang, a Jet Propulsion Laboratory researcher who flew on a space shuttle mission in 1985. Schweickart, who's currently managing an Antarctic safety study for the National Science Foundation, is vice president, and McDonnell Douglas engineer Charlie Walker, who flew on NASA's shuttle three times, is treasurer. New board members include senior captains of space Charles "Pete" Conrad,

Thomas Stafford, and Buzz Aldrin.

Other Soviet-U.S. differences are major. At the 1986 congress, "the Soviets, in private conversation or in groups, tended to express concern that the U.S. space program is moving toward militarization and wanted to speak out," says Overmyer. "We felt that it was not our position to guide the U.S. space program in that sense."

"We are not a lobby organization. We will be a think tank," says Taylor Wang. "What we want to do is provide some service." For instance, if space station designers would like some feedback from people who have lived and worked in space, they can come to the ASE. "We're not out to tell NASA or the Russian space agency, 'Hey, this is what you should do.' But we're ready to help."

"I think that we have to be very careful about not overstating what we can do to keep the dialogue going between the East and West," Overmyer cautions. "It is bound to do some good. It helps people understand each other. If the goals are worthwhile, they're going to be difficult to achieve."

Members agree that talking is the first step, among themselves and to the public at large. To spread the word, ASE members are pairing up for lecture tours. Last year, astronaut-cosmonaut teams toured the United States and the Soviet Union, drawing big crowds. This year the ASE is planning tours in the United States, the Soviet Union, Europe, and perhaps Japan.

ASE members are also writing. A book of essays by ASE members is in the works for publication next year, and this fall a book of photographs of Earth taken from space, interspersed with quotations from ASE members about their experiences, will be published concurrently in the United States and the Soviet Union. Schweickart says the pictures were selected according to only one criterion: beauty. Meanwhile, the ASE's fourth congress will take place in October in Sofia, Bulgaria, hosted by Bulgarian cosmonaut Georgi Ivanov.

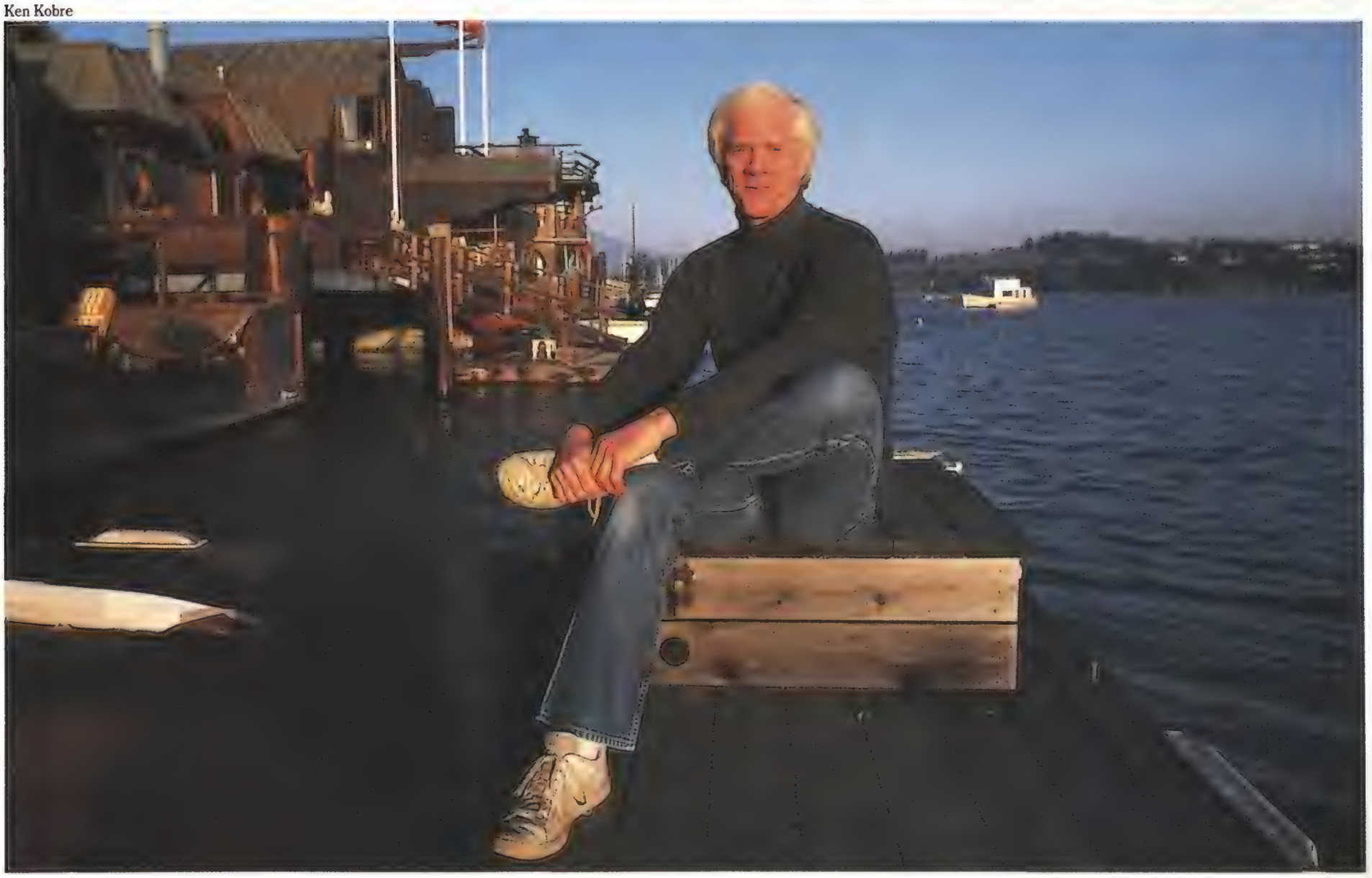
"There are fundamental changes going on in the world because of the marriage between technology and humanity," says Schweickart. "Through communications and travel, we have shrunk the globe to a human scale, and yet we live with continuing cultural, political, and religious boundaries of the past, both physical and nonphysical."

But many people alive today may very well have the chance to work or even live in places other than Earth. "The manner in which we begin this process of civilizing space will set the pattern for generations to come," says Schweickart. Using the technology now at hand, "we can destroy ourselves, or we can enter into the cosmos.

"I have a commitment for the rest of my life," he continues. "In one way or another I will be involved in raising the level of consciousness—my own and other people's—with respect to humankind as it begins to move off this planet. I didn't put that commitment into words during the flight. Now I don't have a choice."

Now studying the Antarctic, Schweickart still finds time to help build a network of space travelers.

Ken Kobre



ONE HUNDRED HAWKS FOR CHINA

The Curtiss P-40 is inextricably linked to the legend of the Flying Tigers. But the maneuvers in Washington to acquire the fighters for China were the stuff of which political legends are made.

by Daniel Ford *Paintings by Paul Salmon*

Partially deaf, suffering from chronic bronchitis, and ostracized professionally for his belief that bombers were vulnerable to fighters, Captain Claire Lee Chennault retired from the U.S. Army Air Corps on April 30, 1937. Eight days later he embarked for China, where the Nationalist government had invited him to serve as a flight instructor.

With the outbreak of the Sino-Japanese War in the summer of 1937, Chennault became aviation advisor to the Nationalist Chinese Air Force under Generalissimo Chiang Kai-shek. He followed the Nationalists as they retreated inland from Nanking to Hankow to Chungking. Safe from invasion but not from aerial attack, Chungking became the ghastly exemplar of the results of "strategic bombing" as it would be practiced in World War II.

His own fighter force destroyed by nimble Japanese fighters, Chiang played a wild card. In November 1940 he sent Chennault to Washington, D.C., to buy U.S. fighters for the defense of Chungking. Chennault had convinced the Generalissimo that a small force of highly trained men, flying aggressively, could take the offensive against the Japanese.

Chinese Nationalist Generalissimo Chiang Kai-shek (above) enlisted U.S. aid for his defense against Japan. Among his most important assets was expatriate American Claire Chennault (left), whom he sent to Washington in late 1940 to shop for fighters.

The Airplane

Given his choice, Chennault would not have picked the Curtiss P-40—or any other airplane with a liquid-cooled engine—to equip his American Volunteer Group in China. Yet in a way he had been present at its creation. As a captain in the Army Air Corps in 1934, he had helped draw up the specifications for the United States' first modern fighter, or "pursuit," as the airplane was called at the time: a low-wing, all-metal aircraft that could fly level at 300 mph. To compete for the resulting business, Curtiss-Wright developed the Hawk 75, which the Army Air Corps would later adopt under the designation P-36. But the airplane was slow and underarmed compared with the warplanes being produced in Europe.

Because its Pratt & Whitney engine was air-cooled, the Hawk 75 had a large frontal surface area, which gave the fighter a stubby, no-nonsense look but did nothing for its aerodynamic efficiency. So Curtiss began to experiment with a liquid-cooled Allison engine manufactured by General Motors. The marriage of Hawk 75 airframe and Allison engine produced the Hawk 81.

In spite of the components it shared with its predecessor—virtually everything except the snout, which was elongated to house the new, narrower engine—the Hawk 81 had a radically different appearance. Like the British Spitfire and the German Messerschmitt 109, it had a sinister look. Unlike them, however, it also seemed to have a face, the result of moving the radiator airscoop to the front of the aircraft, just below the propeller. If the Hawk 81's conical spinner suggested a nose, the airscoop suggested, irresistibly, a mouth. It was inevitable that combat pilots would decorate it with the teeth and staring eyes of a shark.

Claire Chennault cared little for appearances, and even less for liquid-cooled engines. To him they were an abomination, the product of engineers who had never been forced to contend with combat. Under wartime conditions, he believed, radiators and coolant tanks would be vulnerable to bullets or shrapnel, and the complicated fuel system would be fouled with dust and grime. But Curtiss-Wright was convinced that the Allison engine was the only one available that would give its craft the speed to compete with European fighters. Despite its extra weight, the liquid-cooled engine could boost the

streamlined Hawk 81 to a top speed of about 350 mph. The airplane won the Army Air Corps fighter competition in 1939 and was designated the P-40.

The original P-40 had two .50-caliber machine guns that fired slugs at a rate synchronized to the turning of its constant-speed propeller; it also had a .30-caliber machine gun for each wing. Curtiss produced 342 of these airplanes in the summer and fall of 1940. By October, the lessons learned by British and French pilots in the opening months of the European war led to modifications. The P-40B had pilot armor, a second pair of wing-mounted guns, and externally sealed fuel tanks. This model was in turn replaced by the P-40C, the fuel tanks of which had a more effective internal sealing membrane. The

The P-36, with its air-cooled engine, was nosed out of business by the lean and mean-looking P-40.

manufacturer called this third version the Hawk 81-A2; to the Royal Air Force it was the Tomahawk Mark IIB.

With the escalating war threatening even the United States, Franklin D. Roosevelt's "arsenal of democracy" had set out to build 6,000 military aircraft in 1940, 18,000 in 1941, and 50,000 in 1942—more than all other nations of the world combined. The Hawk 81 was the first U.S. fighter produced in significant quantities. It was based on an existing airframe, so Curtiss could rush it into production a full year ahead of competing manufacturers. By November 1940, Allison-powered Hawks were pouring out of a newly built factory in Buffalo, New York, at the then-unprecedented rate of 10 per day.

China, though, had scant chance of obtaining this or any other U.S. fighter. Warplanes were allocated on a priority basis. First in line was the Royal Air Force, which was rebuilding its fighter fleet after the Battle of Britain the previous summer, when the RAF and the Luftwaffe had all but destroyed each other over England. Next was the U.S. Army Air Corps, then beginning its own expansion program. Any left-over airplanes were sorely needed by other European nations, by British Commonwealth forces in the Pacific, by the Netherlands East Indies .... But China? There was no priority for China. In American eyes, the Sino-Japanese War was still a sideshow. If the Chinese had any illusions on this score, they had only to look at the composition of the Joint Allocation Committee, which had been set up in September 1940 to parcel out war materiel. The committee was staffed by representatives of the Army Air Corps, the Navy's Bureau of Aeronautics—and the British Purchasing Commission.

The Deal Makers

T.V. Soong, Chiang Kai-shek's brother-in-law, had been in Washington since June 26, 1940, lubricating the wheels of diplomacy. On July 9, the wily and genial Soong lunched with treasury secretary Henry Morgenthau. Three days later he sent Morgenthau a note suggesting that the United States loan China $50 million to support its currency, $20 million to improve the Burma Road—the 2,100-mile supply line from Rangoon, on the Burmese coast, to the Nationalist capital at Chungking—and $70 million to buy military supplies, including "300 pursuits [and] 100 light bombers with spare parts."

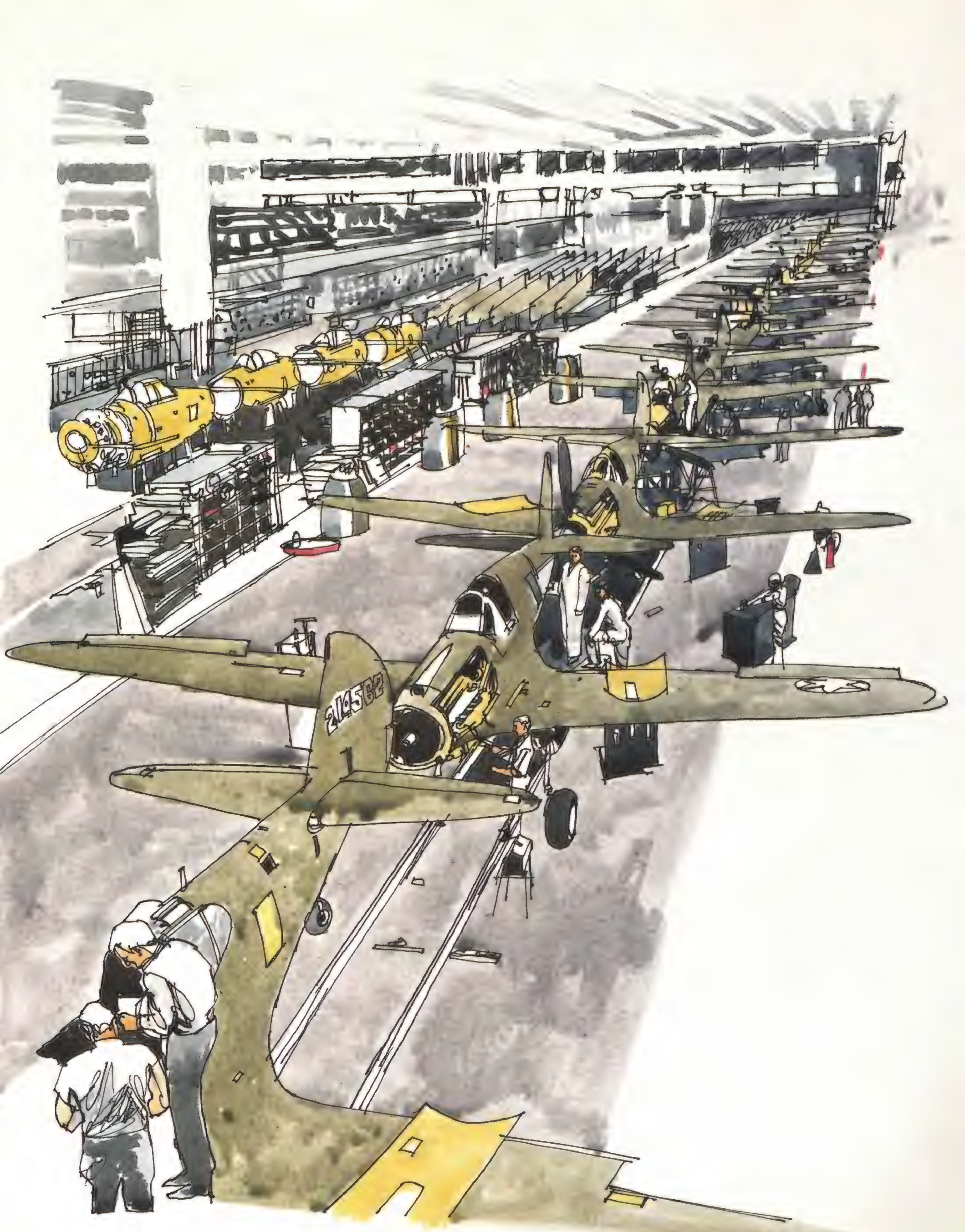
Soong also cultivated such power brokers as Lauchlin Currie, Thomas Corcoran, and Joseph Alsop. The first was a presidential aide, the second had been, and the third was a newspaper columnist who was related to both the president and the president's wife. These were important credentials. Washington still had a small-town power structure, and major deals were transacted through a network of friends.

In November, Soong's one-man China lobby was reinforced by Claire Chennault, plump and handsome General Mao Pang-chu of the Chinese Air Force, and Arthur Young, a financial advisor to Chiang Kai-shek's government. They met in the economist's apartment, with Mrs. Young banished to another room to preserve secrecy. (She heard all, nevertheless. The men spoke loudly in deference to Chennault, whose hearing had been impaired by years of open-cockpit flying.) Young was dismayed by Chennault and Mao's description of the CAF. "China had only 37 fighter planes," he wrote later, "and none that could cope with Japan's Zeros. The only bombers available were 31 of slow Russian types with difficult flying characteristics, that could not be used at night and could be used in daytime only with fighter escort. Anti-aircraft equipment was inadequate and badly worn .... In contrast they stated that Japan had 968 planes in China exclusive of Manchuria, and 120 in Indochina. These included late type fighters and bombers, fast and well-armed."

They worked out "an aviation program," as Young described it, "aimed at protection of Chungking and of the Burma Road." The program was both more ambitious and more specific than Soong's proposal of July 12, calling for 100 of the new Curtiss fighters, 250 radial engine Navy fighters (at Chennault's insistence, one suspects), 100 twin-engine bombers, 10 DC-3 cargo planes, and 150 trainers. It also requested spare parts, anti-aircraft guns, gasoline, and ammunition for a year of combat, the machinery to build 136 new landing fields, and 350 U.S. flight instructors and technicians.

Soong presented his revised shopping list (along with a request that the United States equip 30 Chinese divisions at a cost of $1 million each) to the White House on November 25. The next day he and the Chinese ambassador called upon Secretary of State Cordell Hull to cultivate his support and to

Curtiss-Wright's assembly line production of P-40s helped get the Flying Tigers rolling.



deliver a letter, probably drafted by Chennault, from the Generalissimo to FDR. In it, Chiang suggested that a few hundred U.S. bombers and fighters would enable the CAF to take the offensive against Japanese-occupied Taiwan and Hainan, and even Japan itself.

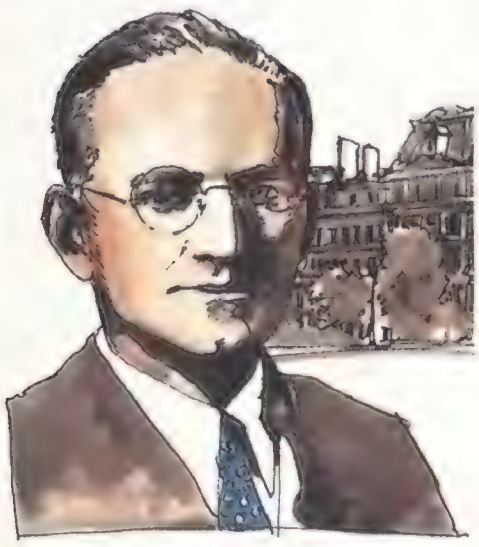
While his brother-in-law made the rounds in Washington, in effect playing the good cop, Chiang Kai-shek stayed in Chungking and played the bad cop. His most effective bargaining chip was the threat posed by the Reorganized National Government in Nanking. Disregarding its ubiquitous regional warlords, China at the end of 1940 had three rival governments: the Nationalists in Chungking, the Communists in Yenan, and a Japanese puppet regime in Nanking under the leadership of Wang Ching-wei. If he emerged as the major force in China, Wang would of course lift a great burden from Japan, which had 750,000 men tied down in fitful combat with Chiang Kai-shek's Nationalist (Kuomintang) army and Communist guerrillas. Chiang Kai-shek sent regular bulletins to Roosevelt about the progress of Wang's government, about Japanese peace overtures, and about German offers to guarantee Japan's peace terms. With China pacified, Japan would be free to move south, obtaining rubber from Indochina and oil from the Netherlands East Indies and possibly joining hands with Germany and Italy across the Indian subcontinent.

Duly alarmed by these reports, FDR had told his advisors to work up a loan agreement to be announced as soon as his reelection was out of the way in November. He also dispatched advisor Lauchlin Currie to see Tommy Corcoran in his office on K Street, four blocks from the White House.

Corcoran's profession was an honorable one at the time,

The power brokers of the day—Henry L. Stimson, Henry Morgenthau, Frank Knox, George C. Marshall, and Cordell Hull (left to right)—met at the state department on December 23, 1940, to divvy up fighters.

although it later fell into disrepute: he made deals for a fee. He cheerfully exploited his White House connections, and in return he did small favors such as the one Currie now asked of him: "Based on my understanding of the [U.S. Congress] I had to predict how much trouble there would be if the president sent modest aid to China [in violation of the Neutrality Act] just to forestall Chiang's surrender," Corcoran wrote in an unpublished manuscript. "I reported back to Currie: there'd be very little trouble as things then stood and were likely to stand in the near future.



FDR sent economist Lauchlin Currie to China in early 1941 to assess Nationalist strength.

"Acting for the president," Corcoran continued, "Currie then suggested that as a private individual I start the paperwork and charter a Delaware corporation to be known as China Defense Supplies .... Frederick Delano, the president's elderly uncle who'd spent a lifetime in the China trade, was a co-chairman of the board [with T.V. Soong] .... My brother David took a leave of absence from Sterling Drug to become president. I remained nominally only the organizer of the firm. By design I took no title, and only earned a modest $5,000 fee for putting the company together."

While China Defense Supplies was being prepared as a conduit for military aid, the lobbying went forward to fund it. On November 29, Morgenthau called a staff conference. "The president just called me up," he noted, "and told me in strictest confidence ... that he is sending part of the fleet to the southern part of the Philippines. He is worried about something going on between Wang and Chiang, and he wants me to make a stabilization loan of $50 million to the Chinese in the next 24 hours."

Newspaper columnist and Roosevelt relative Joseph Alsop backed Chennault from the start.

Next day, on cue, Soong was sitting in Morgenthau's office, blinking benignly through his round spectacles—the good cop. Morgenthau recorded the dialogue in his diary. Soong said that Chiang "asked for between $200 million and $300 million, that is what he asked for."

"What will you take?" asked the pragmatic Morgenthau.

"Well, we are not choosers, Mr. Secretary."

"I see," Morgenthau responded. "But as to take care of the immediate situation, say for six months—"

"I should imagine $100 million."

"I see .... Who else in Washington have you told this to, I mean officially?"

"Of course, I saw the secretary of state," Soong said. "I handed him a memorandum to be presented to the president."

"... Approximately what is in it?"

"Well, just two things [are] in it. One is for airplanes and the second is for [currency] stabilization."

"Well now, was there any time factor in there?" asked Morgenthau.

"It is very urgent because of the Japanese recognition of Wang Ching-wei."

Morgenthau did not forget the bad cop back in Chungking: the Generalissimo could settle with Wang if the United States dragged its feet or came back with a demeaning counter-offer. The treasury secretary had reached the bottom line, and he knew it: "What would you call a minimum that might be helpful?" he asked.

"I should say $100 million," Soong replied.

The Sale

So it was settled, except for the problem of finding the airplanes. But not even this was outside Morgenthau's province, and a solution began to emerge at a meeting at his home the following Sunday. Curtiss-Wright had just begun to build a huge block of Hawk 81-A2s for the Royal Air Force. The RAF began receiving the first of its 630-airplane order in November, and deliveries were scheduled to continue until March 1941. Curtiss happened to have enough parts on hand to build a few hundred extra Tomahawks before changing the production lines to manufacture the Kittyhawk, which had a different profile, a larger engine, and four .50-caliber wing guns. Morgenthau thought that China's needs could be met by extending the Tomahawk production run.

Other countries wanted fighters, too, and on Monday, December 23, a good portion of FDR's cabinet met to work out a formula for allocating the extra airplanes. Cordell Hull convened the meeting in his office. Present were three other cabinet members—Morgenthau, Frank Knox of the Navy Department, and Secretary of War Henry L. Stimson—and assorted military and civilian advisors, including General George C. Marshall, the Army chief of staff. Morgenthau opened the discussion. In the spring of 1941, he said, Curtiss-Wright could turn out 300 fighters beyond its commitments to the RAF and the Air Corps. How should they be spread around? Like boys choosing sides in a sandlot baseball game, the great men began to argue, their words paraphrased by a stenographer:

"Secretary Hull suggested that as the President had promised 30 planes to the Greeks that the 300 P-40's should be divided 150 to China, 120 to South America, and 30 for the Greeks.

"General Marshall said that he had a list of the various South American countries showing how the War Department thought planes should be allocated in that area. Secretary

Wings for the Dragon

China in the 1930s was torn by struggles among feudal warlords, revolution, civil war, and invasion by Japan. For his attempt to unify the country and defeat the Japanese, Generalissimo Chiang Kai-shek needed an air force built from scratch with a few miracles thrown in. One of the miracle workers was Allen "Pat" Patterson.

Born in Canada in 1900, Patterson led an adventurous life. Tall, ash-blond, blue-eyed, and trim, he had been a World War I aviator, a barnstormer, the operator of California's Dycer Airfield, and a flier in the early talkie *Hell's Angels.*

He'd also been vice president and sales manager of the General Airplane Company of Buffalo, New York, before the Crash of '29. In the early days of the Depression, Patterson joined up with Carl Knamacher, the Hudson car company representative in Shanghai, to sell U.S. airplanes to the Nationalist Chinese Air Force (CAF). "I had no difficulty getting the rights to represent the air companies in China," Patterson says. "Everyone thought I was crazy. I got all the big representations, including United Aircraft, Sikorsky, Boeing, Lockheed, and Douglas." But not Curtiss-Wright.

Patterson's new office in Shanghai's International Settlement was just down the hall from that of William D. Pawley, head of the Intercontinent Corporation, local representative for Curtiss-Wright. Just three years older than Patterson, Pawley was socially adept, charming, handsome—and ruthless. When he barged into Patterson's office, he wasted no time on pleasantries.

"You don't think you're going to sell any airplanes here, do you?" Patterson recalls him asking.

Patterson looked him up and down, then asked, "Why not?"

"Because I have an exclusive. Go ask H.H. Kung or General Mao," said Pawley. He turned and walked out.

Patterson came to realize that Pawley used cash and favors freely to smooth his way, and that both Kung, the Nationalist minister of finance, and Mao, chief of the CAF, had been well greased.

Knamacher and Patterson's China Airmotive made its first sale—20 Fleet biplane trainers—to the CAF in 1931. Despite Pawley's machinations, the new company was well afloat by 1932 and being drawn inexorably into the chaos of Chinese politics. In addition to dealing with Chiang, Patterson sold airplanes to a rival Chinese air force in Canton. In 1936, when General Wong Kwong-yue ("Freddy Wong" to the Americans) wanted to bring his Cantonese faction into the Nationalist fold, Patterson played courier, delivering Wong's letter to Madame Chiang. Once its air arm had defected to the CAF, the Cantonese military could only climb aboard the bandwagon, enabling Chiang to make real progress toward unifying China.

Patterson lost his partner Knamacher to a Vought Corsair crash in 1933. With his new partner, Knamacher's Eurasian broker Leslie Lewis, Patterson was drawn further into the maze of Chinese destiny as Chiang's embattled republic loomed larger in Allied plans for the coming Pacific war.

Enter Claire Chennault, who was soon contacted by Bill Pawley. "Pawley told me he has an exclusive on all major aircraft sales to the Chinese Air Force," Chennault said to Patterson.

"The hell he has," Patterson snapped.

"Says he'll make it worth my while to go along," Chennault added.

Pawley had miscalculated: Claire Chennault was not for sale. Furthermore, Chennault strongly favored the Seversky P-35 over the Curtiss P-36 Hawk Pawley was peddling to the Chinese. When Patterson went home to attend the 1937 National Air Races in Cleveland, Chennault gave him a shopping list that included new primary trainers to replace the Fleets. Chennault also asked Patterson to get a contract with Alexander P. Seversky, manufacturer of the P-35, enabling Patterson to represent the Seversky Company in China.

Now the game heated up. Chennault sent his proposal for purchasing P-35s to Pawley's one-time ally, Minister of Finance H.H. Kung. Kung was receptive, but knowing how Pawley operated, he advised Patterson to keep the proposal "top secret." "Submit details to me personally," he added.

Secrecy was short-lived. In Hong Kong, Leslie Lewis received a confidential letter from H.H. Priestly, foreign exchange manager of the Shanghai Banking Corporation, which was arranging financing for the P-35 deal. Pawley had visited the bank manager and "was well equipped with details of the pending contract," Priestly wrote, adding that Pawley had tried to persuade the bank to turn over the credit arrangement proposed by Patterson and Lewis to his own company, Intercontinent. Pawley also claimed that he could obtain better credit terms from the Chinese if the bank would cancel negotiations with Patterson and Lewis. The bank manager turned down Pawley's offers.

While Patterson and Pawley continued their all-out struggle during the first months of 1939, the Chinese delayed a decision. Finally, Kung broke the deadlock. With uncharacteristic directness he summoned the chief engineering officer for the CAF, Colonel Chien, and several of Chien's staff to a meeting in Chungking with Chennault, Patterson, and Lewis. Kung gave Chien 24 hours to tell him why he should not buy the P-35. As Kung suspected, Chien and his staff were already in Pawley's pocket. They raised objection after objection and proposed unfeasible modifications.

On the second day, Kung said, "Since I have heard no valid objections to this purchase, it has been decided to sign."

Patterson flew back to the States in mid-April 1939, his briefcase bulging with the largest single order for military airplanes ever placed by the Chinese government. In addition to 54 Seversky aircraft, Patterson had orders for 25 Vought SB2U-1 Scout Bombers, 70 Ryan Primary Trainers, and 50 North American NA 16-4 Combat Advanced Trainers.

But the game wasn't over. Down but far from out, Pawley took advantage of faulty wording in the Seversky contract. "Guaranteed bond," a British term, probably should have read "surety bond." U.S. banks would not accept the alternative wording and the Chinese ambassador to the United States would not sign for a change of terms—Pawley had gotten to him first.

The rest of the Chinese order was fulfilled without incident, but the victory was tinged with defeat. Seversky Company investors, angered by the loss of the order, voted Seversky out of the president's seat in May and renamed the company Republic Aviation. (The P-35 design eventually evolved into the highly successful Republic P-47 Thunderbolt.)

Later, Chennault was forced to work with Pawley when the latter's Central Aircraft Manufacturing Company became the cover for hiring and administering the American Volunteer Group, but the relationship was far from smooth. Pawley delayed shipment of Chennault's P-40s in 1941, and Central Aircraft's maintenance work for the Volunteers fighting in Burma took second place to work on airplanes that Pawley was selling to the Chinese. Little wonder that AVG veterans resent Pawley's claims of responsibility for their successes. After the war, when Pawley sent a $10,000 check to the Flying Tiger Association with a request to join, the check was returned.

As the Japanese advanced into China, Patterson barely escaped. He went on to head a special Navy project in New Haven, Connecticut, studying the feasibility of replacing metal with wood in aircraft construction. Today Patterson lives in Hong Kong, working as an aviation consultant and manufacturer's representative for the Far East and Southeast Asia.

—Charles Barton

Knox stated that 150 would have to go to the British. To which Secretary Stimson added that the war was in Europe and the Far East, not in South America; therefore the planes [should] go to the British and the Chinese . . . .

"Secretary Hull said that he thought the planes should go to China, and Stimson added that he thought China should get pursuit ships before she got bombers. Secretary Morgenthau inquired as to whether there were any other pursuit ships available that the Air Corps did not like. Major [Patrick] Timberlake said that the Republic P-43 was not particularly well liked by the army as it had no armor and no leak-proof tanks . . . . Admiral [Harold] Stark asked if leak-proof tanks could not be put in those planes, but Major Timberlake said it could not be done.

"Coming back to the P-40, Admiral Stark stated that he thought part of the planes should go to South America. The South American idea, however, was turned down emphatically, and it was resolved that the 300 P-40's should be divided equally between the British and the Chinese . . . . After a good deal of discussion, however, it was decided that if the British gave up current deliveries to the Chinese, then the British should receive planes on a two for one basis. In other words, the British would give up to the Chinese 50 in January, 25 in February, and 25 in March, making a total of 100, but she would get back 300 later in the spring, giving her a net gain of 200. Secretary Morgenthau said he would get in touch with the British right away and ask them to place the order."

On January 10 the British agreed to this proposition. The RAF would give up 100 of their Tomahawks during the first three months of 1941, and in return would get all the airplanes to be built at the end of the scheduled production run.

Also in early January, Chennault laid the groundwork for the recruitment of the First American Volunteer Group, the men who would fly and maintain the fighters. AVG pilots and technicians—given FDR's special dispensation to resign from the U.S. Armed Forces—set out for Southeast Asia in the summer and fall of 1941.

The Consignment

Diverted as they were from a British allocation, Chennault's fighters were painted in RAF "sand and spinach" camouflage—alternating bands of tan and green—except for their undersides, which were pale blue to blend with the sky. (Air Corps P-40s were painted olive drab above, light gray below.) More significantly, the British infantry rifle of the day—the bolt-action Enfield—took a cartridge differing in small but important details from that used by the U.S. Army. The RAF had specified that the Tomahawk wing guns be built to handle the Enfield rounds, and 64 of the airplanes diverted to China were thus equipped. The others, for reasons now impossible to fathom, were delivered without any armament whatever; these had to be fitted with machine guns scrounged up in the Far East. As a result, Chennault's Volunteers would go into combat with four different ammunition requirements: .303-inch British, .30-inch U.S., and .317-inch Chinese rounds for their wing guns, plus the .50-inch rounds for the nose guns.

The RAF and the Army Air Corps also used different radio frequencies. The British had therefore ordered their fighters without communications equipment, planning to install their own sets. But China Defense Supplies could obtain neither RAF nor Army Air Corps equipment, and instead shipped 100 RCA radios designed for light sportplanes. AVG pilots often went into combat unable to talk to the control tower or to one another.

T.V. Soong used $4.5 million of his recently acquired funds to pay for these "bastard aircraft," as Joseph Alsop described them. As each of the 36 Hawks made for China in January came off the production line, it was fitted into two huge crates, one for fuselage and engine, the other for wing assembly,

Thomas Corcoran brought politics and business acumen into play in U.S.-China negotiations.

propeller, and empennage. The crates were loaded onto flatcars and sent by rail to New York, where they were transferred to a Norwegian freighter. The ship sailed at the end of February, headed for Burma by way of South Africa and the Indian Ocean. Unknown to Chennault, his little air force had already been reduced by one: during loading, a wing crate fell into the New York harbor. It was hoisted out and stowed with the rest, but by the time the freighter reached Rangoon, saltwater corrosion had ruined the assembly. The fuselage to which it belonged was immediately cannibalized for parts.

The easterly route required two extra weeks, and in early March Soong petitioned the state department for the remaining shipments to be sent westward in U.S. freighters through the Panama Canal and across the Pacific. Impossible, said State. Burma was a British colony, Britain was at war, and the Neutrality Act forbade U.S. vessels from carrying war materiel to the port of any belligerent. The second lot of Hawks—32 of them—was shipped late in March via the same tedious route and under the same impartial flag.

At this juncture, an entrepreneur named William Pawley turned up in Washington with a 1933 Curtiss-Wright contract assuring him a commission on any of its airplanes sold in China. He demanded the contractual 10 percent, as if he had brokered the sale. Curtiss refused to pay, whereupon Pawley threatened to embargo the airplanes still in New York. An exasperated Henry Morgenthau called a meeting in his office on April 1, during which Pawley agreed to waive his claim in return for a $150,000 contract to assemble the airplanes in Burma. Morgenthau decided to capitulate—if you can't beat

T.V. Soong practiced the art of persuasion to obtain supplies for brother-in-law Chiang's regime in China.

When the shark-nosed Hawks arrived in China, the Flying Tigers became a carnivorous mixed metaphor.

him, hire him (see "Wings for the Dragon," p. 85).

All obstacles cleared at last, the final lot of 32 Hawks left New York toward the end of April.

In July Roosevelt approved a bomber group and a second fighter group for China, but because the airplanes were not shipped before the Japanese attack on Pearl Harbor, the Volunteers fought with only the airplanes sent in early 1941. A

dozen were wrecked in training, and dozens more were sidelined for lack of replacement parts. At no time did Chennault have more than 55 combat-worthy fighters.

The wider war transformed the mission of the AVG. With his tiny force, Chennault had to defend the Burma Road from December 8, 1941, to July 4, 1942, by which time Burma was lost and the Volunteers inducted into the U.S. Army Air Forces. His gallant mercenaries—known to the world as the Flying Tigers—had compiled an astonishing record against a far superior force, destroying 297 Japanese aircraft in the air and on the ground. (Japanese records indicate that the tally was much exaggerated, while any AVG veteran will swear that it is conservative.) For their part, the Flying Tigers lost most of their Hawks and 23 of their men, all but one of them fliers. Three other pilots were captured by the Japanese but survived the war.

Stars and the Man

Aldous Huxley's essay "Stars and the Man" has a curious and circuitous history. In the spring of 1953 Huxley began work on a profile of his friend, astronomer Edwin Hubble. Though Hubble discovered the structure and expansion of the universe, he was and remains largely unknown outside the scientific community. Huxley set out to rectify that by publishing the essay in Esquire *magazine, to which he contributed regularly.*

Hubble died a few months after the piece was finished, so Huxley never published it. Huxley's manuscript was destroyed when his house burned in 1961, and Esquire *kept no record of the essay.*

Recently, while working on a book about Hubble, California writer Tom Bezzi came across a reference to the essay in a journal kept by Hubble's wife. After considerable sleuthing, Bezzi found a copy of the piece among her papers and incorporated it into his book, Hubble Time, *a fictional portrayal of the Hubbles and their set. The following is an excerpt from "Stars and the Man" as it appears in* Hubble Time.

Seven hundred years ago, every schoolboy knew that the radius of the universe, from its center (which was, of course, the center of the earth) to the surface of the outermost heaven, or firmament, was precisely 109,375 Roman miles. By 1620, when Burton was writing *The Anatomy of Melancholy,* the distance from the earth to the eighth sphere had increased very considerably. The radius of the universe was now 170,000,803 miles. But the concentric spheres of the older system were already going out of fashion. The Copernican Revolution was in full swing, and Burton's younger contemporaries knew that the earth was a planet, revolving, with its fellow satellites, about a central sun. By the middle of the eighteenth century, the solar system had been measured with a high degree of accuracy. But exact knowledge ended with the orbits of the planets. All that could be said about the fixed stars was that they must be a long way off. Not until 1840 was the distance of

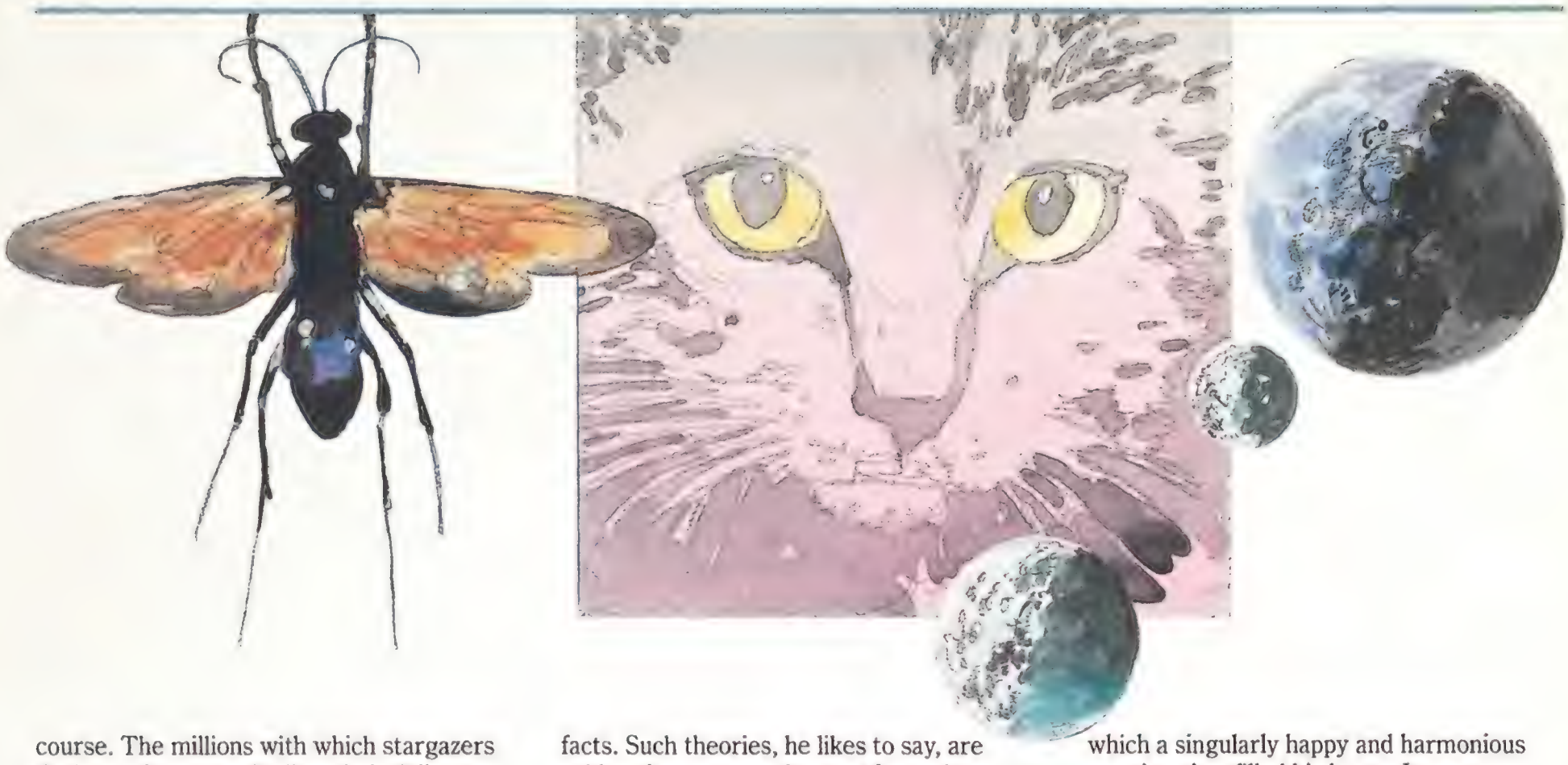
Illustrations by Paul Salmon

one of the nearer stars precisely measured. In that year Bessel was able to observe the parallax of Alpha Centauri and to calculate that the star was at a distance of a little more than four light-years—in other words, about twenty-five million million miles—from the solar system. How far away were the stars with no observable parallax? Ten times as far? A hundred times? It was anybody's guess.

This was where the matter stood when I was a boy, at the beginning of the present century. Then, almost suddenly, another intellectual revolution took place—a revolution no less momentous than the Copernican shift from a tiny nest of spherical boxes centered upon the earth to a solar system within a much larger configuration of stars. The history of this second great revolution in cosmological thought may be followed in the successive editions of the Encyclopaedia Britannica. In the edition of 1910 there is an excellent article by Eddington on the nebulae. In this article it is taken for granted that all the nebulae, of whatever type, are within our own galactic system, at no greater distance from us than the remotest of the stars. Twelve years later the Britannica was brought up to date by the issue of three supplementary volumes. In the first of these volumes is an article on Astronomy, also by Eddington. It contains the announcement of the first phase of the revolution. The spiral nebulae are now described as "island universes," outside our own system of stars. By 1928, when the fourteenth edition of the Britannica made its appearance, astronomers were making the first tentative estimates of the remoteness of these islands in outer space. Distances of millions, even tens of millions, of light-years are mentioned in the new article on nebulae, and the author closes with an almost purple passage about the incomprehensible vastness of the cosmos. Today the universe of 1928 seems almost cozy. The 200-inch reflector has revealed nebulae at a distance of a thousand million light-years, and all the island universes in the corner of infinite space accessible to our observations are apparently receding from us at a rate, proportionate to their distance, of hundreds or even thousand [*sic*] of miles a second.

The man who, more than any other single individual, is responsible for this new revolution in cosmological thought, is Dr. Edwin Hubble. For the universe as we know it today—infinitely improbable, fathomlessly mysterious—rests in the main on Hubble's observations. (For the interested reader, there are Hubble's original papers and his classical monograph, *The Realm of the Nebulae*, together with a small library, popular as well as technical, on astronomy and cosmology.) My concern here is not with science as such, but with one particular man of science, and with that man of science in his relations to the world outside the observatory.

In this context, the most remarkable fact about Edwin Hubble is his catholicity, his all-roundedness. This great researcher in the purest of the pure sciences is widely and profoundly cultivated; this inhabitant (almost literally) of an ivory tower on a mountain top is also a complete human being and the best of good citizens. And yet, from the very first, astronomy was his manifest destiny. On his fourth birthday little Edwin was told to choose his treat. Instead of ice cream or a visit to the circus, he asked to be allowed to sit up late so that he might watch a meteor shower which was expected that night. At the age of eleven he wrote an exhaustive treatise on Mars, which was printed in the local newspaper; it was his first astronomical publication. Through his boyhood and adolescence, astronomy dogged him like a guilty conscience. At the University of Chicago, the Hound of Heaven was at his heels. There was a general viewing with alarm and, at Oxford, where he went as a Rhodes Scholar, Hubble did his best to escape. He studied law. And for a whole year, after his return to the United States, he practised as an attorney—very successfully. Then the Hound caught up with him. He took down his shingle and returned to Chicago for post-graduate work in his predestined subject. The budding corporation lawyer was no more; the astronomer had been reborn. There was no money in it, of



course. The millions with which stargazers deal are of years and miles; their dollars are reckoned only by hundreds. But what did it matter? The important thing was that a manifest destiny was in process of fulfillment.

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After World War I, Hubble moved to Southern California and worked with the 100-inch reflector atop Mt. Wilson. Soon he established that the Andromeda nebula is outside our own galaxy, that the universe is made up of billions of galaxies, and that light from each galaxy is "redshifted"—made redder—as the galaxy gains distance from the observer.

After serving in World War II, Hubble turned his attention to the 200-inch telescope on Mt. Palomar.

[A]t last the great telescope was in operation. From the heights of Palomar new facts came showering down. The radius of the known universe jumped overnight to a billion light-years, and even at a third of that distance the nebulae were seen to be rushing away from us at thirty thousand kilometers a second. In their studies, meanwhile, the theorists were hard at work, extrapolating and inferring, postulating and drawing conclusions from the postulates. There were the men of the Big Bang school, who maintained that everything had started, four or five billion years ago, with a cosmic explosion. Ranged in opposition were the proponents of the Steady State Universe—the men who, like Hoyle and Gold and Bondi, believed in a process of continuous creation. The argument continues. Hubble listens, but takes no sides. He is an observer and has all the observer's polite skepticism in regard to theories which cannot be tested against facts. Such theories, he likes to say, are subject for conversation, not for serious scientific dissertation. Conversation is delightful and stimulating; but it must always be taken with a grain of salt. While the others dispute of the nature of the unknown and the unknowable, Hubble patiently extracts from the tiny blurs and dots of photographic negatives fresh information about the unimaginably distant worlds, with which the new cosmology has peopled the infinity of space.

The effects of any given scientific discovery upon the philosophy by which men actually live are hard to predict. How precisely will man's world view be modified by this latest, this more than Copernican revolution, for which the great telescopes and their users, above all Edwin Hubble, have been responsible? . . . [I]t may be pertinent to ask how the chief author of that cosmology feels about the world, what he thinks of human beings and their destiny.

Hubble has never ventured into the field of systematic philosophy, and a certain natural reserve, a distaste for psychological exhibitionism, has kept him from every form of autobiography or self-revelation. But . . . he has at least dropped a few significant hints.

***

Religion, in Whitehead's phrase, is what a man does with his solitude—what he does with his solitude in relation to other individuals and *their* solitude; what he does with his solitude in relation to the other-than-human world without and the other-than-human worlds, from the physiological to the spiritual, within his own being. In this sense of the words, Hubble's religion is a profound Natural Piety. It expresses itself in that atmosphere of active serenity, with which a singularly happy and harmonious marriage has filled his home. It expresses itself again in that love, quiet but passionate, instinctive but informed, for trees, flowers, grasses, everything that lives and grows. I have seen him in the cactus garden of the Huntington Library, at Pasadena, standing in a kind of rapture, at once aesthetic, mystical and scientific, before the fantastic black and emerald green blossoms of a South American puya; have watched him in the desert enjoying silently, intensely, the yearly miracle of lilies out of the desolation of life, indomitably beautiful, in the dry dunes and among the rocks. And the same Natural Piety characterizes his relations with animals. Hubble seems not merely to know, but actually to feel, to realize with his entire being, his kinship with them; and this felt kinship excludes all sentimentality, all patronage, all indifference. He loves animals with the humorous, understanding affection which is true charity. The wild things return his gift with interest. They will eat out of his hand, perch on his shoulder, permit themselves, if they are hurt, to be taken, held, worked upon. Between the man of the nebulae and the extraordinary black creature called Nicolas Copernicus, who shares his house and who, three hundred years ago, would undoubtedly have been burned as a familiar, or even a witch in his own right, there exists a strange telepathic intimacy. The shyest, wildest, most intransigent of individualists, Nicolas Copernicus remains nevertheless acutely conscious of all that his human friend is feeling, of his impending departures from home and the approaching moment of his return. And when the man is sick, the cat keeps watch with untiring devotion at the foot of the bed—only to retreat again into a wild aloofness as soon

as the illness has taken a definitely favourable turn.

But it is in fishing that the astronomer's Natural Piety finds its most satisfying outlet. Sometimes, when he is camping in the mountains and there are no other sources of food, he fishes for his dinner. But mostly he fishes in the spirit of that Old Man who, as Chuang Tzu records, was seen by Prince Wen Wang "fishing, not in order to catch fish, but to amuse himself. So Wen Wang wished to employ him in the administration of government, but feared lest his own ministers, uncles and brother might object. On the other hand, if he let the old man go, he could not bear to think of the people being deprived of such an influence." Fishing for fishing's sake, Hubble employs a barbless hook and returns his trout to their native element, in the hope that this experience of being caught may teach them the rudiments of fishy wisdom. And meanwhile, all around him, are the enormous vacancies of the Rockies or the Sierra, the humanized Nature (if he happens to be fishing on the other side of the Atlantic) of those meadows, those low hills, those embowered church spires, which are the same today as they were when Izaak Walton cast his homemade flies. And as he wades in the torrent, or stands on the green bank above the sliding water, there comes that sense of "something far more deeply interfused"; that consciousness of being intensely oneself and yet at one with stream and sky, with the trees and the wild flowers, with the poised or darting shapes of the fish, with the bees, the dragon-flies, the invisible wren soliloquizing in the bushes. This "obscure knowledge," as the mystics call it, is of eternity in the perpetual perishing of Nature, of infinity in this spray of willow leaves, this rock, this white cloud. It inspired Thoreau and Whitman; it is the theme of all Wordsworth's greatest poetry; it is a diffused radiance (for though obscure, this knowledge illuminates) in all that Chaucer wrote; it flashes like lightning in Blake and Shakespeare; it is the very essence of that Liberation offered by Zen Buddhism and expressed, or rather hinted at, in Sung painting, in the landscapes of the Japanese masters who were inspired by that painting, in the *haiku*, those vanishingly brief and yet immeasurably pregnant poems by Basho and his successors.

From the holiday solitudes of trout streams, the fisherman returns to the professional solitudes of midnight on Palomar. Under the huge dome he waits in patience for the sky to clear, hopes against hope for one of those miracles of perfect seeing which occurs less and less frequently as the size of telescope [*sic*] increases. (One such miracle took place on the night of November 26th, 1924, when the 100-inch reflector took its finest picture and revealed the individual stars within a spiral nebula.) He sits there listening to the silence, listening to those nocturnal sounds which intensify the silence.

Stillness!
The voice of the cicada
Sinks into the rocks.

And sinks, still more impossibly, into the realm of the nebulae. For such sounds constitute, in Thoreau's words, "a sort of rudimental music, suitable to the ear of night, and the acoustics of her dimly lighted halls."

And now the clouds are gone. The photographic plate is slipped into position and, as the telescope turns, picks up the faint and, to human eyes, invisible light that started on its pilgrimage a thousand million years ago. The positive knowledge that is science is being collected. But for the observer, meanwhile, there is the obscure knowledge of oneness in difference, of the absolute otherness that is yet identical with the ground and the essence of the perceiving mind.

From the book Hubble Time *by Tom Bezzi. Copyright © 1987 by Tom Bezzi. Reprinted through permission of Mercury House.*

When Pancakes Flew

If aeronautical engineer Charles H. Zimmerman had had his way, the Navy would have been flying pancakes instead of serving them in mess halls.

Zimmerman flew in the face of conventional design with his 1940s Navy fighter. The Vought XF5U-1 was designed to take off and land vertically, to slow to a virtual hover, and to zip along at 500 mph. It was an aeronautical oddity that was unmistakably pancake-shaped. But due to last-minute Navy waffling, the "Flying Pancake" never flew.

An earlier Pancake, the V-173, did get off the ground and in fact flew a total of 131 hours. Vought chief test pilot Boone T. Guyton made most of the flights at Bridgeport Airport in Stratford, Connecticut. Writing later for the *Historical Aviation Album,* Guyton recalled, "The initial flight . . . was one of the most interesting I had made in my career as a professional pilot." No doubt. Upon completion of the V-173's 13-minute maiden flight on November 23, 1942, Guyton " felt exalted and had a foolish impulse to yell, 'Charlie, she flies!' "

Zimmerman couldn't have been surprised. He had been working on the concept of an elliptical flying wing for over a decade, convinced that combining powerful rotor-like propellers and a low-aspect-ratio body would result in a craft that could perform over a wide range of speeds. Zimmerman's research indicated that counter-rotating propellers at the leading edge of an airfoil could counteract wingtip vortices, that a circular form offered great structural strength, and that a pilot lying prone could endure higher G loads than one sitting up straight. He was right. In 1933, while employed by the National Advisory Committee for Aeronautics (the forerunner of NASA), Zimmerman entered a flying wing in a NACA lightplane design competition and won. NACA declined to develop the aircraft, however, deeming the concept too advanced.

By 1939 Zimmerman had moved to Chance Vought, where he built a remote-controlled Pancake that performed well enough to persuade the Navy to sponsor the V-173, a full-fledged prototype. After wind tunnel tests at NACA's Langley Field in Virginia, Guyton made his exhilarating first flight.

During five years of test flights, only two major problems emerged: insufficient

The full-blown Pancake flopped when jet engines made propellers obsolete.

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Although it was underpowered, the V-173 made nearly 200 test flights.

Windows in the V-173's nose helped the pilot see better during landings.

power—two three-blade propellers, each powered by an 80-horsepower Continental engine, were barely adequate to propel the one-and-a-half-ton wood-and-fabric craft—and pilot discomfort, exacerbated by poor visibility, due to the required prone position. (The V-173 was modified to allow the pilot to sit up, and a window was installed between the pilot's feet to provide visibility during landings, though Guyton claimed he never used it.)

In general, the strange-looking machine lived up to Zimmerman's expectations. The V-173 was controllable at a 45-degree angle of attack, could take off within 200 feet, landed at under 50 mph, and, despite Guyton's best efforts, would not stall or spin. The V-173's top speed in level flight was only 138 mph, however, and true vertical flight was impossible—a problem both Zimmerman and the Navy blamed on low-power engines.

The Pancake's sturdiness was dramatically demonstrated during an emergency landing necessitated by a vapor lock in the fuel line: forced to land on a beach, pilot Richard Burroughs swerved to avoid a sunbather, and the Pancake, true to its name, flipped over. By the time a rescue crew arrived, Burroughs had clambered out unhurt. The aircraft, too, was unscathed.

All this persuaded the Navy to proceed with construction of the XF5U-1. Its two Pratt & Whitney R-2000-7 Twin Wasp engines, producing 1,350 horsepower apiece, would solve the power problems. The airplane was also given two specially designed four-blade propellers. The wing structure and surfaces were made primarily of Metalite, a new balsa-aluminum composite that was both sturdy and light.

Fabrication began in Bridgeport, Connecticut, in 1943, and rollout followed in 1945. The craft was painted midnight blue, and the "nose" sported Bugs Bunny riding a magic carpet, based on artwork by the Warner Bros. studio.

Guyton and his colleagues made taxi and other ground tests at the Vought factory over the following 18 months, resulting in a little fine-tuning. Flight testing was scheduled at the Muroc Dry Lake facility (now Edwards Air Force Base) in California. But on March 17, 1947, just as the Pancake was being readied for shipping through the Panama Canal, the Navy telegrammed that the project was canceled. The Pentagon had seen the future, and the future was jets.

Another propeller-driven fighter seemed an unjustifiable expense. The contract was terminated and the Flying Pancake terminally grounded: Navy brass ordered the aircraft demolished. The reason for the destruction order is a mystery. "I have never found anything that explains why the Pancake was destroyed," says Navy aviation historian John Elliott.

The XF5U-1 was wrecked—with some difficulty, bolstering its reputation for strength—in 1948. The partially disassembled V-173 at the National Air and Space Museum's facility in Suitland, Maryland, is all that remains of Zimmerman's vision of Flying Pancakes.

—Katie Janssen

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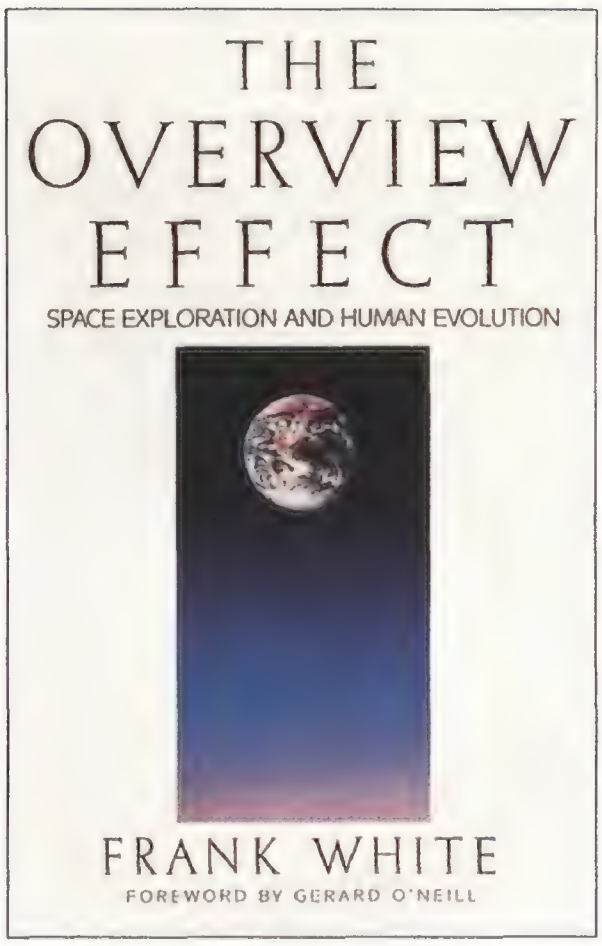
The Overview Effect: Space Exploration and Human Evolution *by Frank White. Houghton Mifflin Company, 1987. 318 pp., $18.95 (hardbound).*

Astronauts are often asked to describe their experiences in space. Almost as often, the descriptions they give prove somehow unsatisfying to their questioners. But according to Frank White, "The problem may not be that the astronauts can't describe their experiences, but that *we can't hear what they're saying.* The astronauts have tried to explain the experience to us, often in quite eloquent language . . . . But a shared context is critical for real communication to take place." The average citizen, in White's view, does not yet share the astronauts' context because he has not experienced the "Overview Effect"—a new perspective, gained from achieving a vantage point in space, that enables astronauts to recognize Earth as an interconnected ecosystem.

And yet the Earthbound Everyman keeps trying to extract some kernel of insight from space travelers because he understands that the astronauts' experiences are at the leading edge of mankind's collective consciousness. Writes White, "The idea of Earth as one system is fundamental to the development of a new civilization of which Earth is a part and a whole at the same time, and the picture of the whole Earth is the symbol of that civilization."

White, a senior associate of Gerard K. O'Neill's Space Studies Institute (space expert O'Neill wrote the book's foreword), believes that spaceflight is more important as a catalyst for global consciousness-raising than for any of its scientific or political benefits, and that NASA's efforts to justify a space program solely on the basis of scientific significance "has helped create a public perception that the space program is a technological feat with minor impact on the lives of ordinary people. As research on the Overview Effect has shown, nothing could be further from the truth . . . ."



White may even underestimate the impact his hypothesized Overview Effect has already had here on Earth. In 1988 there are a substantial number of adults who were born after 1961, the year Yuri Gagarin made the first orbit of Earth. While this group hasn't experienced spaceflight directly, it has been immersed in spaceflight imagery—the photographs, television and film footage, posters, and even advertising that have saturated our culture with views of Earth from space. Even an airline passenger can get a diluted form of the experience necessary to achieve the Overview Effect.

White sometimes stretches his arguments too thin. And he stretches his readers' patience with the final third of the book, which consists of transcripts—and worse, "reconstructions"—of interviews with astronauts. *The Overview Effect* is, nonetheless, a thoughtful and thought-provoking addition to the literature on spaceflight.

—Katie Janssen, Associate Editor

A Missing Plane *by Susan Sheehan. Berkley Books, 1988. 244 pp., b&w illustrations, $3.50 (paperback).*

During World War II, some 350 Australian and U.S. aircraft disappeared over the eastern part of New Guinea. In 1983 Susan Sheehan saw a small item in *The New York Times* about the discovery of one of those airplanes, a B-24 that had crashed in 1944 in the dense jungle of the Owen Stanley Range. According to the article, authorities had located the families of all but one of the 22 men on board the ill-fated bomber. That one man, the copilot, had been married just four months. Anyone with information about his next of kin was asked "to notify the Adjutant General's Casualty Office with a collect call." Sheehan, a Pulitzer Prize-winning author who had "always wanted to do a story about missing people," was intrigued. This stunning little book, tracing the story of the missing plane and the men who were aboard, was the result of her investigation. Newly published in paperback, *A Missing Plane* appeared first in *The New Yorker* in 1986 and later in a hardback edition.

With the drama of a Le Carré thriller and the detail of a medieval illuminated manuscript, Sheehan takes us from the crash site on Mt. Thumb to a cramped Army forensic laboratory in Hawaii and finally, for a haunting profile of pilot Robert Allred, back to Depression-era America. Sheehan has the unusual ability to shape a story out of elements that would normally make for dull reading: official Army Air Corps records, an 11th grader's autobiography, a pilot's log, pages and pages of highly technical data compiled by a physical anthropologist. And she makes her work memorable with a diligent search for answers to several underlying questions: What was it like to be a young and cocky aviation cadet in World War II? How does a forensic investigator identify 22 men from a handful of broken bones and teeth 40 years after their death? What is it like for wives and fathers and mothers to feel the shock and pain of this sure knowledge so long after their loved ones' disappearance?

In answering these questions, Sheehan meditates on fate and the role it played in the course of events. Had it not been for the obsession of Bruce Hoy of the National Museum and Art Gallery of Papua New Guinea, for example, the aircraft might well have remained undiscovered. (Hoy plans to locate and identify every missing World War II aircraft in Papua New Guinea.) And had the identification of the remains been assigned to someone other than coroner Tadao Furue, many of the men aboard

aircraft 42-41081 when it careened into the earth at 150 mph may well have remained, in official parlance, "missing in action, presumed dead." (Other identifications made by Furue have been challenged by relatives of the casualties. An Army investigation into the matter exonerated Furue but sharply criticized the equipment, techniques, and staffing of his laboratory.)

Sheehan's book is as much about heroic gesture—in particular the pursuit of knowledge—as it is about the frustrations of dealing with bureaucracies and a situation that, as far as many of the next of kin were concerned, had been resolved in 1946, when they received "presumed dead" notifications. Hoy, Furue, and Sheehan refused to let it go at that. Crisply written and brilliantly conceived, *A Missing Plane* is an unforgettable book.

—Douglas McCreary Greenwood is a pilot and Washington, D.C. writer.

Falcon *by Spectrum HoloByte. For IBM-compatible computers (256K RAM with DOS 2.x; CGA, EGA, or Hercules Graphics Card Plus; RGB Monitor) and Apple Macintosh Plus and SE. Joystick optional but recommended; $49.95. Reviewed in the IBM version.*

From 25,000 feet the three buildings are specks in the desert. My mission is to bomb one of them. As I close in at 440 knots, 78 percent power, and a heading of 180 degrees, I am one with my machine, an F-16 Fighting Falcon.

I switch the HUD (head-up display) into the air-to-ground mode and note that the active weapons are two Mk 84s—2,000-pound general-purpose bombs. Zeroing in on one of the buildings, I push the stick forward and begin a shallow dive. The altimeter unwinds: 24 thousand feet . . . 22 . . . 20 . . . 18 . . . . My pulse quickens. My fingers twitch. The HUD shows I'm locked on to the target. Fourteen thousand feet . . . 12 . . . 10 . . . . The bombsight centers on the target and I squeeze the trigger.

Six thousand feet . . . four . . . two . . .

Pull up. Pull up. Kick in the afterburner. Climb. Climb. Climb, I shout to myself.

I check my six o'clock. There's nothing left where the building was but a black hole and an "X" to mark the spot. I have left nothing but wanton destruction in my wake. I push the stick to the left, do a victory roll, and level out.

Mission accomplished. It's time to head home, but I haven't the foggiest idea how to land. Fortunately, it's just a game. I press "P" to pause and turn to page 31 for further instructions.

Falcon is a fighter simulation that turns your computer into the cockpit of an F-16. The instruction manual runs a daunting 132 pages, but even that provides only minimal instructions for shooting down enemy MiGs and destroying bridges, airfields, enemy headquarters, and surface-to-air missile sites. I needed hours before I could successfully take off and find the buildings I wanted to waste. (I suffered a delay once when, curious about the controls, I blew up the runway in front of me.) I've yet to make a landing that anyone could walk away from.

To compensate for its intricacy, the game is forgiving of beginners. Flying at the First Lieutenant rank means unlimited fuel and armament and relative ease hitting MiGs. It is impossible to crash or get shot down. The program lets you lower your landing gear after you've landed. And even if you auger in at 600 knots you can roll your fighter right-side up, pull back on the stick, take off, and still get a message that reads "Mission Complete. Nice Job" when you finish the game.

At the rank of Colonel, the enemy has become more ominous and the game is more realistic. A player may have to fight as many as three MiGs at once. The screen will fade to black during maneuvers in excess of 8 Gs. And a pilot who ejects behind enemy lines may be captured; being taken prisoner of war, like being killed in action, is a permanent condition in Falcon. The duty roster keeps track of these and other sundry details.

I've never flown an F-16 but I can imagine this is what it's like. The only things missing are the physical sensations—you can't *feel* the G forces when you add full power and climb at 80 degrees. The sound effects are puny: firing up the engines sounds more like fingernails screeching along a blackboard than a Pratt & Whitney F-100 roaring to life. (The Macintosh version is supposed to have better sound effects.) And the visual clues clearly lack realism. You can't simply turn your head to see what's to the left, or glance at the control panel to see your fuel gauge—you have to remember which button to push to give you a right, rear, or left view. By then you could be waxed by the enemy.

But none of this is the fault of the program; it's the consequence of trying to be a combat hero while sitting behind a desk.

—Elaine de Man is a freelance writer who lives and plays games in Alameda, California.

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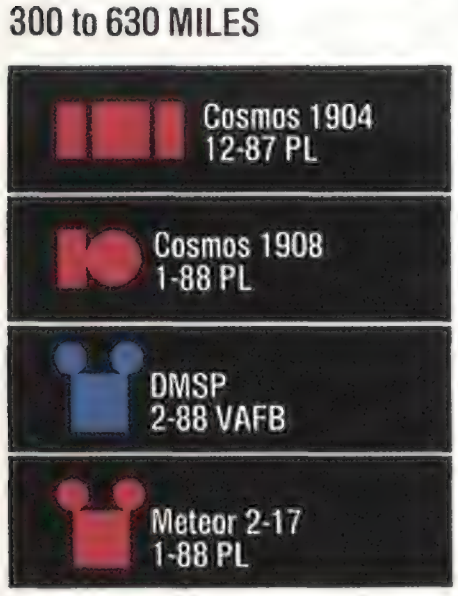
300 to 630 MILES



630 to 1,250 MILES

21,750 to 22,370 MILES

Additional satellite

21,750 to 22,370 MILES

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Cosmos 1896 down 12-25-87	Progress 33 down 12-19-87
Cosmos 1899 down 12-21-87	Soyuz TM-3 down 12-29-87

Launched but not in orbit

90 to 300 MILES

Cosmos 1905 USSR photo recon	12-25-87	down 1-8-88
Cosmos 1907 USSR photo recon	12-29-87	down 1-12-88
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Credits

Burning Ambitions. Fred Reed is a frequent contributor to *Air & Space/ Smithsonian.*

Sea Serpents and Steel Forests. Jim Griffin is a member of the Eagle Squadron Association.

Further reading: *The Eagles' War,* Vern Haugland, Jason Aronson Inc., 1982.

The Chariot of Indra. Sheila Tefft is a correspondent in south Asia for the *Chicago Tribune* and *Business Week.*

Avinash Pasricha works in New Delhi, India, where he is photo editor for *SPAN,* a U.S. Information Agency publication.

The Deregulation Diet. Elaine de Man's goal is to fly first class for the rest of her life.

Artful Fliers. As a schoolboy, Henry S. Villard watched the first Gordon Bennett race at New York's Belmont Park in 1910. He first flew in an airplane on July 4, 1912, when a French army pilot took him up in a 70-horsepower biplane.

X-29. Stephan Wilkinson follows the wisdom of an airline captain-sage—"Straight-and-level pays better." Though he has never flown a jet fighter, he has piloted over 110 more docile aircraft.

Barron Storey's lifelong interest in aviation was sparked by an airplane that was built by his father and powered by a Henderson motorcycle engine. He wanted to be an aeronautical engineer, but Storey became an artist when he found his talent was in drawing airplanes rather than designing them.

Further reading: *The X-Planes,* J. Miller, Specialty Press, 1983.

Grumman X-29, B. Gunston, Aeoleus, 1985.

The Hundred-Mile-High Club. J.E. Ferrell is a science and technology writer for the *San Francisco Examiner.*

One Hundred Hawks for China. A novelist and journalist, Daniel Ford is writing a history of the American Volunteer Group.

Further reading: *P-40 Hawks at War,* J. Christy and J. Ethell, Scribner's, 1980.

Chennault: Giving Wings to the Tiger, M. Byrd, University of Alabama Press, 1987.

Wings for the Dragon. Charles Barton is the author of *Howard Hughes and His Flying Boat* (TAB Books, 1982).

TODAY'S DEFENDER WEARS A DIFFERENT KIND OF ARMOR.

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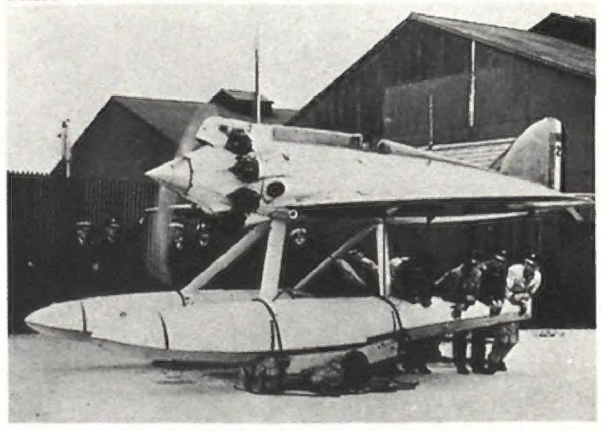
In the Wings...

The Schneider Harvest—On September 13, 1931, George Stainforth flew unopposed in the final race for the Schneider Trophy. His victory that day was anticlimactic, but in the preceding decade the race advanced seaplane technology in ways that would alter the course of World War II. And relationships between European and U.S. competitors mirrored interwar political developments.

NASM



Barrier Reef Airline—Kevin and Sue Bowe have built their Air Whitsunday from the waterline up. A thousand miles north of Sydney, Australia, the Bowes' fleet provides service to tourists, yachtsmen, and divers. An Air Whitsunday excursion is "more than just another joy flight," Kevin says. "We decided to provide a total reef experience." They do—right down to using pilots experienced in scuba diving, boating, and ecological education.

Archeology From the Air—The pursuit of long-buried artifacts was once the dirtiest of disciplines. Now some archeologists keep their fingernails clean by conducting research from the air and even from space: using infrared imagery and other remote sensing techniques, they have located promising sites for their trowel-and-sieve colleagues.

Terry Gwynn-Jones

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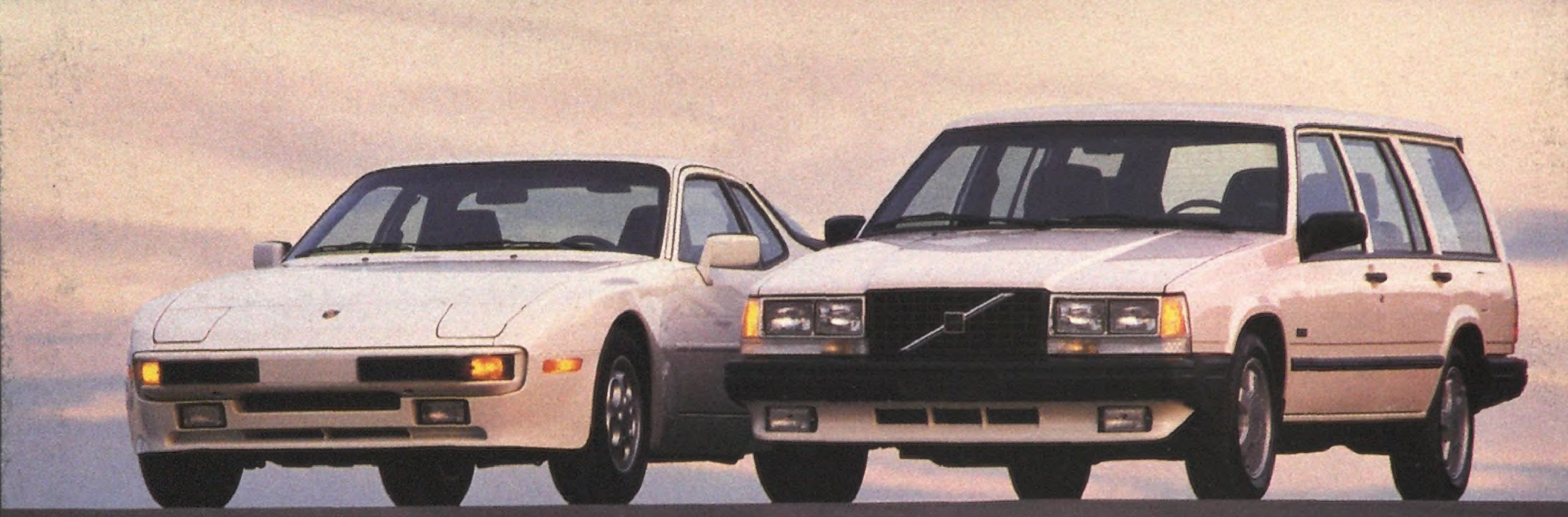

TO A RADAR GUN THEY LOOK EXACTLY ALIKE.

Forget the fact that the car on the left is a legendary performance car. And that the one on the right is a wagon.

A radar gun doesn't notice minor details like that. It focuses on only one thing: speed.

And from that point of view, the Porsche 944 and the Volvo 740 Turbo Wagon look remarkably similar.

In fact, in repeated quarter-mile tests, they came up with virtually identical numbers—both in elapsed time and miles-per-hour. In 0-60 tests, the Volvo wagon actually came out ahead of the Porsche.* Which is no small feat for *any* car. much less a wagon.

It's no wonder *Road & Track* magazine called the 740 Turbo Wagon the closest thing to a five-door sports car.

Which all goes to prove that the Volvo 740 Turbo Wagon is something very rare indeed:

A wagon that's actually worth owning for what it packs up front.

VOLVO
A car you can believe in.

*BASED ON INDEPENDENT ACCELERATION TESTS.